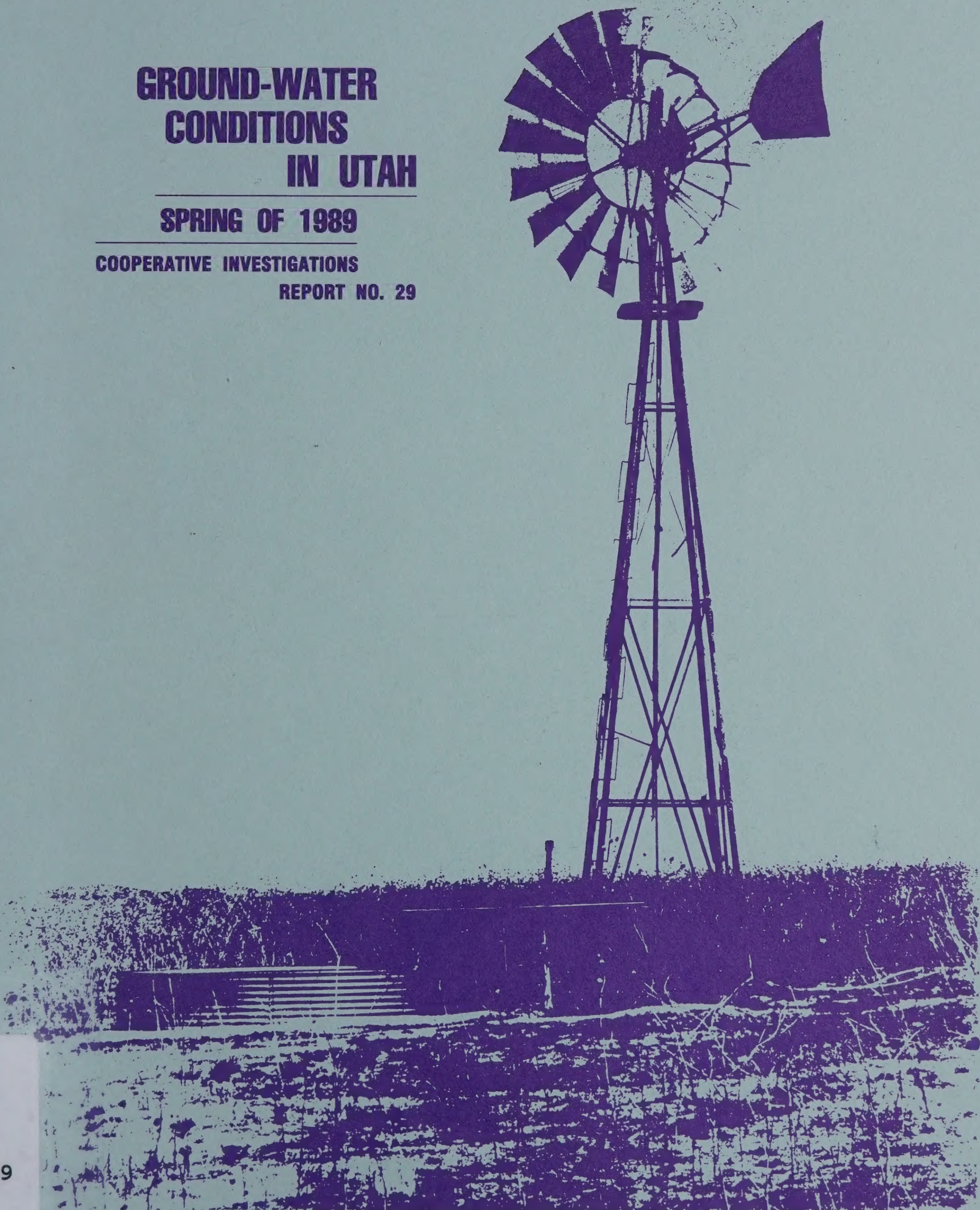
GROUND-WATER CONDITIONS IN UTAH

SPRING OF 1989

COOPERATIVE INVESTIGATIONS REPORT NO. 29



UTAH DIVISION OF WATER RESOURCES • UTAH DIVISION OF WATER RIGHTS • U.S. GEOLOGICAL SURVEY

GROUND-WATER CONDITIONS IN UTAH, SPRING OF 1989

by

Carole B. Burden and others

United States Geological Survey

Prepared by the United States Geological Survey

in cooperation with the State of Utah,

Division of Water Resources and

Division of Water Rights

Published by

Division of Water Resources

Utah Department of Natural Resources

Cooperative Investigations Report Number 29

1989

CONTENTS

ILLUSTRATIONS

Page

TABLES

CONVERSION FACTORS

Most values in this report are given in inch-pound units. Conversion factors to metric units are shown below.

Multiply	by	To obtain
Acre-foot	1233	Cubic meter
Foot	0.3048	Meter
Inch	25.40	Millimeter
Mile	1.609	Kilometer

Chemical concentration is given only in metric units-milligrams per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million.

GROUND-WATER CONDITIONS IN UTAH, SPRING OF 1989

by

Carole B. Burden and others
U.S. Geological Survey

INTRODUCTION

This is the twenty-sixth in a series of annual reports that describe ground-water conditions in Utah. Reports in the series, published cooperatively by the U.S. Geological Survey and the Utah Division of Water Resources, provide data to enable interested parties to keep abreast of changing ground-water conditions.

This report, like the others in the series, contains information on well construction, ground-water withdrawals from wells, water-level changes, and related changes in precipitation and streamflow. Supplementary data such as graphs showing chemical quality of water and maps showing water-level contours are included in reports of this series only for those years or areas for which applicable data are available and are important to a discussion of changing ground-water conditions.

The report includes individual discussions of selected major areas of ground-water development in the State for the calendar year 1988. Water-level fluctuations, however, are described for the period from the spring of 1988 to the spring of 1989. Much of the data used in the report were collected by the Geological Survey in cooperation with the Division of Water Rights, Utah Department of Natural Resources.

The following reports dealing with ground water in the State were released as Open-File reports, printed by the U.S. Geological Survey, printed by cooperating agencies, or published in conference proceedings during 1988:

Ground-water conditions in Utah, spring of 1988, Gail E. Cordy and others, Utah Division of Water Resources Cooperative Investigations Report 28.

Hydrology of the Navajo Sandstone in southeastern and southern Utah, P.J . Blanchard, in McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United States--Aquifers of the western mountain area: American Water Resources Association Monograph Series No. 14.

Upper Colorado River Basin regional aquifer-systems analysis--Mesozoic rocks in Arizona, Colorado, New Mexico, Utah, and Wyoming, G.W. Freethey, in McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United States--Aquifers of the western mountain area: American Water Resources Association Monograph Series No. 14.

Lithologic and hydrologic properties of Mesozoic rocks in the Upper Colorado River Basin, G.W. Freethey, in McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United-States--Aquifers of the western

mountain area: American Water Resources Association Monograph Series No. 14.

Ground-water flow systems of western Utah, J.S. Gates and M.S. Bedinger, _in_ McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United States--Aquifers of the western mountain area: American Water Resources Association Monograph Series No. 14.

Ground water in the Great Basin part of the Basin and Range Province, western Utah, J.S. Gates, _in_ Kepp, R. S., and Cohenour, R. E., eds., Cenozoic geology of western Utah, sites for precious metal and hydrocarbon accumulations: 1987 Symposium and Field Conference, Utah Geological Association Publication 16, p. 75-89.

Geochemistry of water associated with the Navajo Sandstone aquifer, San Rafael Swell area, Utah, B.A. Kimball, _in_ McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United-States--Aquifers of the western mountain area: American Water Resources Association Monograph Series No. 14.

Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the middle Green River basin, Utah, 1986-87, D.W. Stephens, Bruce Waddell, and J.B. Miller, U.S. Geological Survey Water-Resources Investigations Report 88-4011.

Sources of hydrologic data on Mesozoic formations in the Upper Colorado-River Basin and comparison of data analysis methods, J.F. Weigel, _in_ McLean, John S., and Johnson, A. Ivan, eds., Regional aquifer systems of the United-States--Aquifers of the western mountain area: American Water Resources Association Monograph Series No. 14.

Geohydrology of the Navajo Sandstone in western Kane, southwestern Garfield, and southeastern Iron Counties, Utah, Geoffrey W. Freethey, U.S. Geological Survey Water-Resources Investigations Report 88-4040.

Models, data available, and data requirements for estimating the effects of injecting saltwater into disposal wells in the greater Altamont-Bluebell oil and gas field, northern Uinta Basin, Utah, Geoffrey W. Freethey, U.S. Geological Survey Open-File Report 88-475.

Selected hydrologic data for Pahvant Valley and adjacent areas, Millard County, Utah, 1987, Susan A. Thiros, U.S. Geological Survey Open-File Report 88-195.

Major ground-water flow systems in the Great Basin region of Nevada, Utah, and adjacent States, J.R. Harrill, J.S. Gates, and J.M. Thomas, U.S. Geological Survey Hydrologic Investigations Atlas HA-694-C.

UTAH'S GROUND-WATER RESERVOIRS

Small quantities of ground water can be obtained from wells throughout much of Utah, but large supplies that are of suitable chemical quality for irrigation, public supply, or industrial use generally can be obtained only in specific areas. The major areas of ground-water development discussed in this report are shown in figure 1 and named in table 1. Relatively few wells outside of these areas yield large supplies of water of good chemical quality for the uses listed above, although some of the basins in western Utah and many areas in eastern Utah have not been explored sufficiently to determine their potential for ground-water development.

About 2 percent of the wells in Utah obtain water from consolidated rocks. The consolidated rocks that yield the most water are lava flows, such as basalt, which contain interconnected vesicular openings, fractures, or permeable weathered zones at the tops of flows; limestone, which contains fractures or other openings enlarged by solution; and sandstone, which contains open fractures. Most of the wells that tap consolidated rocks are in the eastern and southern parts of the State in areas where water supplies cannot be obtained readily from unconsolidated deposits.

About 98 percent of the wells in Utah draw water from unconsolidated deposits. These deposits may consist of boulders, gravel, sand, silt, or clay, or a mixture of some or all of these materials. Wells obtain the largest yields from the coarser materials that are sorted into deposits of uniform grain size. Most wells that tap unconsolidated deposits are in large intermountain basins, which have been partly filled with rock material eroded from the adjacent mountains.

SUMMARY OF CONDITIONS

The estimated total withdrawal of water from wells in Utah during 1988 was about 821,000 acre-feet, which is about 47,000 acre-feet, or 6 percent, more than the revised estimate for 1987 and about 79,000 acre-feet, or 11 percent, more than the average annual withdrawal for 1978-87 (table 2). The increase in withdrawal was predominantly for public supply, which was about 231,000 acre-feet in 1988, an increase of 40,000 acre-feet, or 21 percent, from 1987 (table 2). Withdrawal for irrigation was about 442,000 acre-feet, which is 7,000 acre-feet, or 2 percent, more than the estimate for 1987. Withdrawal for industrial use was about 79,000 acre-feet, the same as the 1987 estimate.

Of the 16 major areas of ground-water development referred to in this report (table 2), only six areas, Cedar Valley (Iron County), Parowan Valley, the Milford, Beryl-Enterprise, and central Virgin River areas, and upper and central Sevier Valleys and upper Fremont River valley, showed decreases in ground-water withdrawals in 1988. Withdrawals in Juab Valley and in the Sevier Desert equaled 1987 estimates. Withdrawals in 9 of the 16 areas exceeded the 1978-87 annual average for each area, and the withdrawals were less than or equal to the average in the remaining 7 areas (table 2).

The quantity of water withdrawn from wells is related to demand and availability of water from other sources, which in turn are partly related to local climatic conditions. Calendar year 1988 was the first year of generally less-than-average precipitation in Utah after six years of greater-than-average precipitation. Of the 33 weather stations throughout Utah for which graphs and bar charts of cumulative departure from average

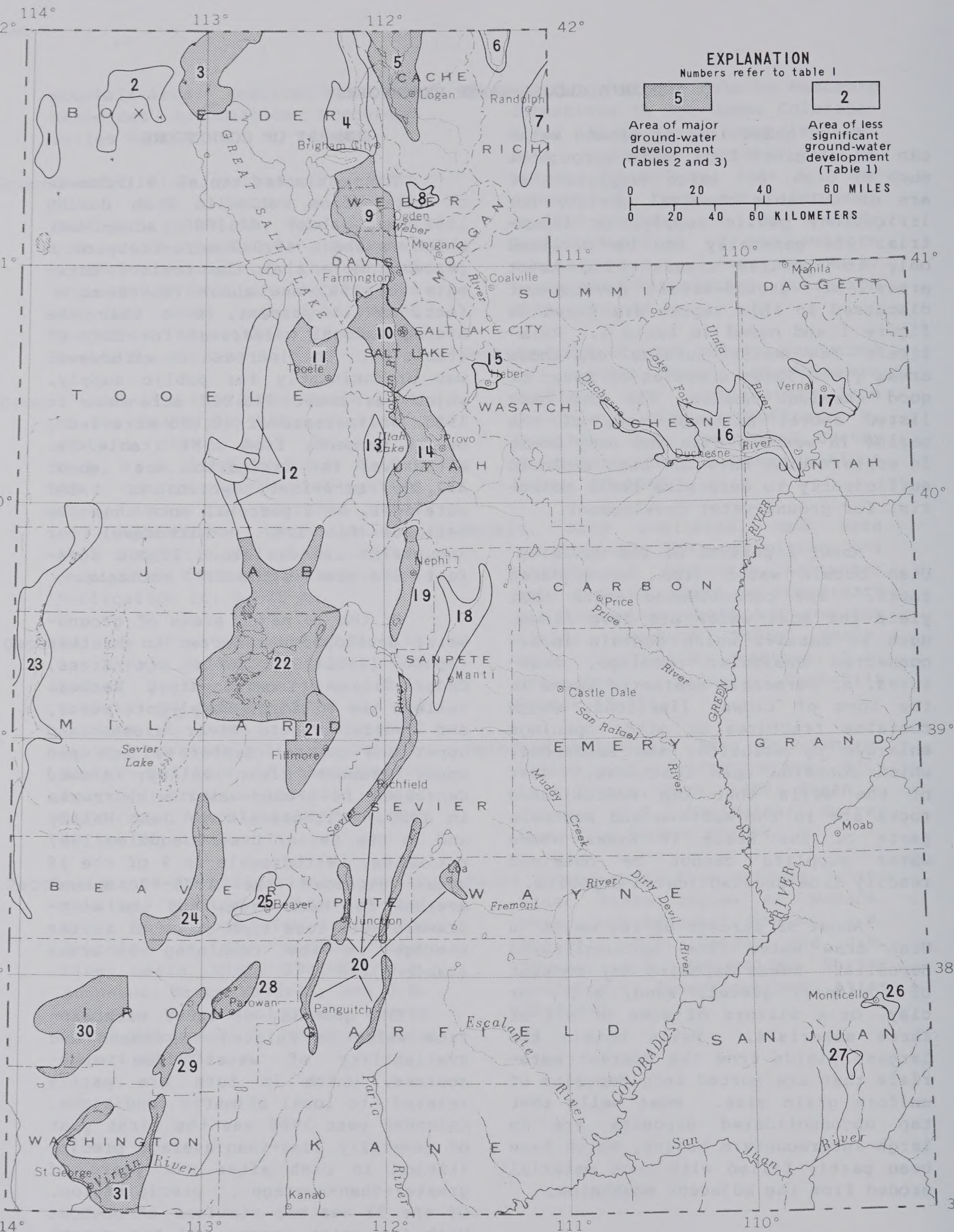


Figure 1.—Areas of ground-water development specifically referred to in this report.

Table 1.—Areas of ground-water development in Utah specifically referred to in this report

Number in figure 1	Area	Principal type of water-bearing rocks
1	Grouse Creek Valley	Unconsolidated
2	Park Valley	Do.
3	Curlew Valley	Unconsolidated and consolidated
4	Malad-lower Bear River valley	Unconsolidated
5	Cache Valley	Do.
6	Bear Lake valley	Do.
7	Upper Bear River valley	Do.
8	Ogden Valley	Do.
9	East Shore area	Do.
10	Salt Lake Valley	Do.
11	Tooele Valley	Do.
12	Dugway area	Do.
	Skull Valley	Do.
	Old River Bed	Do.
13	Cedar Valley, Utah County	Do.
14	Utah and Goshen Valleys	Do.
15	Heber Valley	Do.
16	Duchesne River area	Unconsolidated and consolidated
17	Vernal area	Do.
18	Sanpete Valley	Do.
19	Juab Valley	Unconsolidated
20	Central Sevier Valley	Do.
	Upper Sevier Valleys	Do.
	Upper Fremont River valley	Unconsolidated and consolidated
21	Pahvant Valley	Do.
22	Sevier Desert	Unconsolidated
23	Snake Valley	Do.
24	Milford area	Do.
25	Beaver Valley	Do.
26	Monticello area	Consolidated
27	Blanding area	Do.
28	Parowan Valley	Unconsolidated and consolidated
29	Cedar Valley, Iron County	Unconsolidated
30	Beryl-Enterprise area	Do.
31	Central Virgin River area	Unconsolidated and consolidated

annual precipitation are included in this report, 25 stations recorded precipitation less than the average annual value. In recent years, less-than-average precipitation was recorded at 13 stations in 1987, 7 stations in 1986, 9 stations in 1985, and 0 to 5 stations in 1982-84. For 1988, less-than-average precipitation was recorded in the valleys of central Utah and along the Wasatch Front from Provo to Logan. The largest negative departure from average precipitation, about 12 inches, was recorded at Silver Lake near Brighton.

Greater-than-average precipitation was recorded at 8 stations in Utah in 1988, mostly in the southwestern part of the State. The largest positive departure, about 4 inches, was recorded at St. George.

Measurements of water levels in 776 wells during February and March 1989 indicate that water levels declined in about 70 percent of the wells when compared to a similar period in 1988. Declines in water levels were noted in more than 75 percent of the wells in Salt Lake Valley, Curlew Valley, and the Milford and Beryl-Enterprise areas. Water-level declines were measured in about 60 percent of the wells in Pahvant Valley and the Sevier Desert. These declines are probably related to less-than-average precipitation in 1988 compared to 1987 and a related decrease in discharge and an increase in ground-water withdrawals for public supply, irrigation, and industrial uses.

Cedar Valley (Iron County), Parowan Valley, and the central Virgin River area were the only parts of the State where the number of wells with water-level rises substantially outnumbered the wells showing declines. Precipitation measured at weather stations in these areas was greater-than-average for 1988. The water-level rises are probably related to decreases in ground-water withdrawals due to the availability of greater supplies of surface water in 1988 compared to 1987 resulting from precipitation that was greater in 1988 than in 1987.

The total number of wells drilled during 1988 (table 2), taken from reports by well drillers filed with the Utah Division of Water Rights, was about 15 percent less than the number reported for 1987. Of the 463 wells drilled in 1988, 217 were for new appropriations of ground water, an increase of 27 percent from the number reported in 1987, and 54 were replacement wells, which is a decrease of 45 percent from the number reported in 1987. The remaining 192 wells include test and monitoring wells. Twenty large diameter wells (12 inches or more), mostly for withdrawal of water for public supply, irrigation, and industrial use, were drilled in 1988, 33 percent less than in 1987.

The large ground-water basins and those experiencing most of the ground-water development in Utah are shown in figure 1. Information about the number of wells constructed, withdrawals of water from wells for principal uses, and total withdrawals during 1988 for the major areas of ground-water development is presented in table 2. Annual withdrawals from major areas of ground-water development for 1978-87 are shown in table 3.

Table 2.—Well construction and withdrawal of water from wells in Utah

Number of wells constructed in 1988.--Data provided by Utah Department of Natural Resources, Division of Water Rights. Includes test wells and replacement wells.

Diameter of 12 inches or more.--Constructed for irrigation, industry, or public supply.

Estimated withdrawals from wells.--

1987 total: From Cordy and others (1988, table 2), as revised.

1978-87 average annual: Calculated from previous reports of this series and also includes some previously unpublished revisions.

Area	Number in figure 1	Number of wells constructed in 1988		Estimated withdrawals from wells (acre-feet)						
				1988						
		Total	Diameter of 12 inches or more	Irrigation	Industry	Public supply	Domestic and stock	Total (rounded)	1987 total	1978-87 average annual
Curlew Valley	3	9	0	33,800	0	50	50	34,000	29,000	27,000
Cache Valley	5	19	0	14,200	8,100	9,100	1,800	33,000	26,000	25,000
East Shore area	9	36	1	(1)17,200	10,300	36,000	4,500	68,000	67,000	49,000
Salt Lake Valley	10	89	1	4,160	(2)10,600	101,000	25,300	141,000	122,000	116,000
Tooele Valley	11	21	0	(1)21,500	1,400	2,400	300	26,000	22,000	25,000
Utah and Goshen Valleys	14	45	0	49,600	3,500	39,900	20,000	113,000	(3)104,000	(3)91,000
Juab Valley	19	3	0	20,100	0	(4)1,200	300	22,000	22,000	15,000
Sevier Desert	22	5	0	10,500	2,500	1,500	300	15,000	15,000	19,000
Upper and central Sevier Valleys and upper Fremont River valley	20	4	1	12,300	300	2,100	6,000	21,000	22,000	23,000
Pahvant Valley	21	2	0	70,000	100	370	300	71,000	66,000	(3)67,000
Cedar Valley, Iron County	29	3	1	17,100	500	2,400	400	20,000	21,000	25,000
Parowan Valley	28	2	2	(5)19,600	300	70	200	20,000	22,000	25,000
Escalante Valley										
Milford area	24	2	0	33,400	(6)6,000	700	250	40,000	44,000	50,000
Beryl-Enterprise area	30	8	7	67,800	(7)19,500	410	750	88,000	97,000	88,000
Central Virgin River area	31	10	4	7,500	1,600	8,800	250	18,000	20,000	20,000
Other areas(8)		205	3	42,900	14,800	24,600	8,700	91,000	75,000	77,000
Totals (rounded)		(9)463	20	442,000	79,000	231,000	69,000	821,000	(3)774,000	(3)742,000

(1) Includes some domestic and stock use.
(2) Includes some use for air conditioning, about 30 percent of which is reinjected into the aquifer.
(3) Previously unreported revision.
(4) Includes some industrial use.
(5) Includes some use for stock.
(6) Withdrawal for geothermal power generation. Approximately 5,500 acre-feet was reinjected.
(7) Includes 19,400 acre-feet pumped to dewater a mine and used as recharge in adjacent area.
(8) Withdrawals are estimated minimum. See page 72 for withdrawal estimates for other areas.
(9) Includes 217 wells drilled for new appropriations of ground water and 54 replacement wells. Data from Division of Water Rights, Utah Department of Natural Resources.

Table 3.--Total annual withdrawal of water from wells in major areas of ground-water development in Utah, 1978-87

[From previous reports of this series.]

Area	Number in figure 1	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1978-87 average (rounded)
		Thousands of acre-feet										
Curlew Valley	3	27	29	30	40	26	18	20	27	26	29	27
Cache Valley	5	26	28	25	33	26	20	21	22	23	26	25
East Shore area	9	36	46	45	36	38	43	49	67	66	67	49
Salt Lake Valley	10	120	125	129	127	115	110	102	110	104	122	116
Tooele Valley	11	30	30	27	30	26	22	23	22	21	22	25
Utah and Goshen Valleys	14	104	107	94	101	86	74	78	88	75	[1] 104	[1] 91
Juab Valley	19	19	21	15	21	16	6	6	11	10	22	15
Sevier Desert	22	40	45	13	18	16	8	10	13	11	15	19
Upper and central Sevier Valleys and upper Fremont River valley	20	26	24	24	25	28	21	20	21	22	22	23
Pahvant Valley	21	[1] 79	[1] 85	[1] 77	[1] 83	[1] 70	42	42	[1] 62	60	66	[1] 67
Cedar Valley, Iron County	29	31	32	28	29	28	21	20	23	19	21	25
Parowan Valley	28	29	30	28	27	25	22	22	25	24	22	25
Escalante Valley												
Milford area	24	58	49	61	69	55	39	32	49	46	44	50
Beryl-Enterprise area	30	71	79	71	93	99	86	95	100	93	97	88
Central Virgin River area [2]	31	20	20	20	22	27	16	19	21	20	20	20
Other areas		92	92	70	83	100	52	64	77	68	75	77
Totals		[1] 808	[1] 842	[1] 757	[1] 837	[1] 781	600	623	[1] 738	688	[1] 774	[1] 742

[1] Previously unpublished revision

[2] Prior to 1984 included under 'Other Areas'

MAJOR AREAS OF GROUND-WATER DEVELOPMENT

CURLEW VALLEY

by G.J. Smith

Withdrawal of water from wells in Curlew Valley in 1988 was approximately 34,000 acre-feet, an increase of 5,000 acre-feet from the amount reported for 1987 and 7,000 acre-feet more than the average during 1978-1987 (table 2).

Water levels in Curlew Valley generally declined from March 1988 to March 1989 due to increased withdrawals for irrigation and less-than-normal recharge from less-than-average precipitation. Water levels rose slightly in the west-central part of the valley (fig. 2).

The relation of water levels in two selected observation wells to cumulative departure from average annual precipitation at Snowville and to annual withdrawals from wells is shown in figure 3. Precipitation at Snowville in 1988 was 8.72 inches, which is 3.78 inches less than the average annual precipitation for 1941 through 1988. The hydrograph for well (B-14-9)7bbb-1 is representative of irrigated areas near Snowville. Well (B-12-11)16cdc-1 is on the edge of the irrigated area near Kelton. Water levels in these wells apparently are affected by fluctuations in precipitation and ground-water withdrawals in the valley.

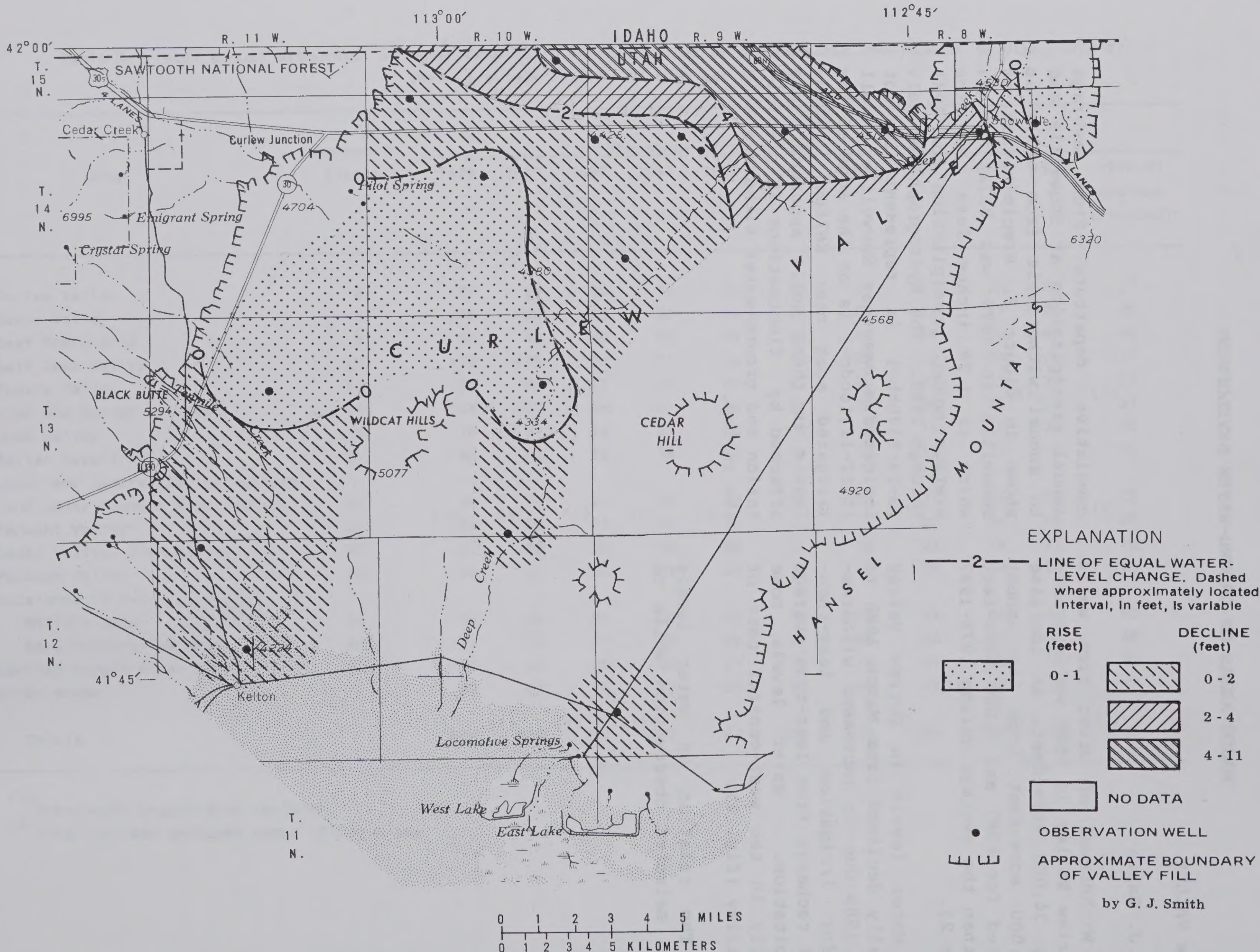


Figure 2.--Map of Curlew Valley showing change of water levels from March 1988 to March 1989.

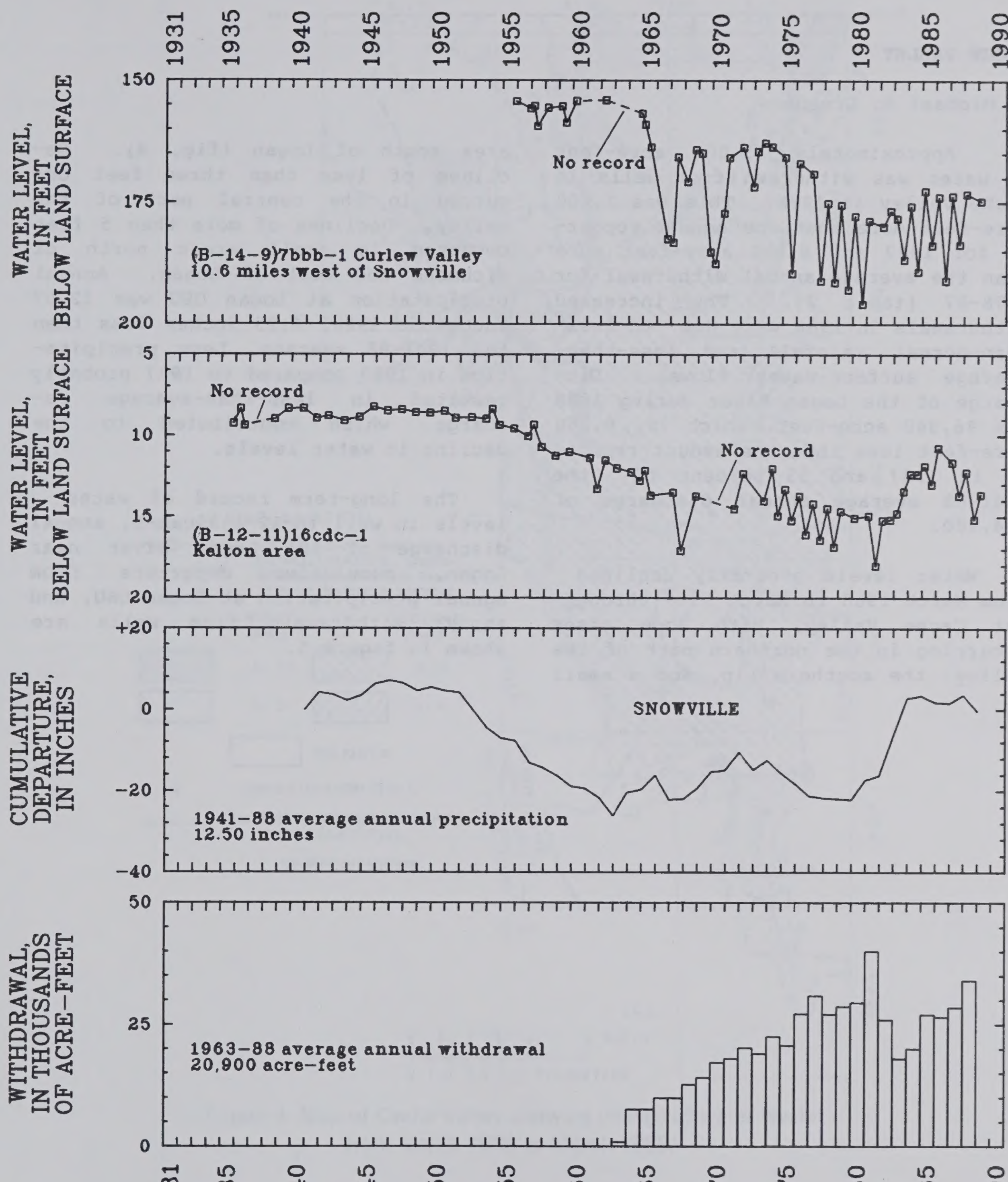


Figure 3.--Relation of water levels in selected wells in Curlew Valley to cumulative departure from the average annual precipitation at Snowville and to annual withdrawals from wells.

CACHE VALLEY

by Michael R. Greene

Approximately 33,000 acre-feet of water was withdrawn from wells in Cache Valley in 1988. This was 7,000 acre-feet more than the amount reported for 1987 and 8,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). The increased withdrawals in 1988 were due to less-than-normal rainfall and less-than-average surface-water flows. Discharge of the Logan River during 1988 was 96,940 acre-feet, which is 8,260 acre-feet less than the amount reported in 1987 and 53 percent of the 1941-88 average annual discharge of 184,700.

Water levels generally declined from March 1988 to March 1989 throughout Cache Valley, with some rises occurring in the northern part of the valley, the southern tip, and a small area south of Logan (fig. 4). Declines of less than three feet occurred in the central part of the valley. Declines of more than 5 feet occurred in small areas north of Richmond and west of Logan. Annual precipitation at Logan USU was 12.57 inches in 1988, 6.23 inches less than the 1941-88 average. Less precipitation in 1988 compared to 1987 probably resulted in less-than-average recharge, which contributed to the decline in water levels.

The long-term record of water levels in well (A-12-1)29cab-1, annual discharge of the Logan River near Logan, cumulative departure from annual precipitation at Logan USU, and annual withdrawals from wells are shown in figure 5.

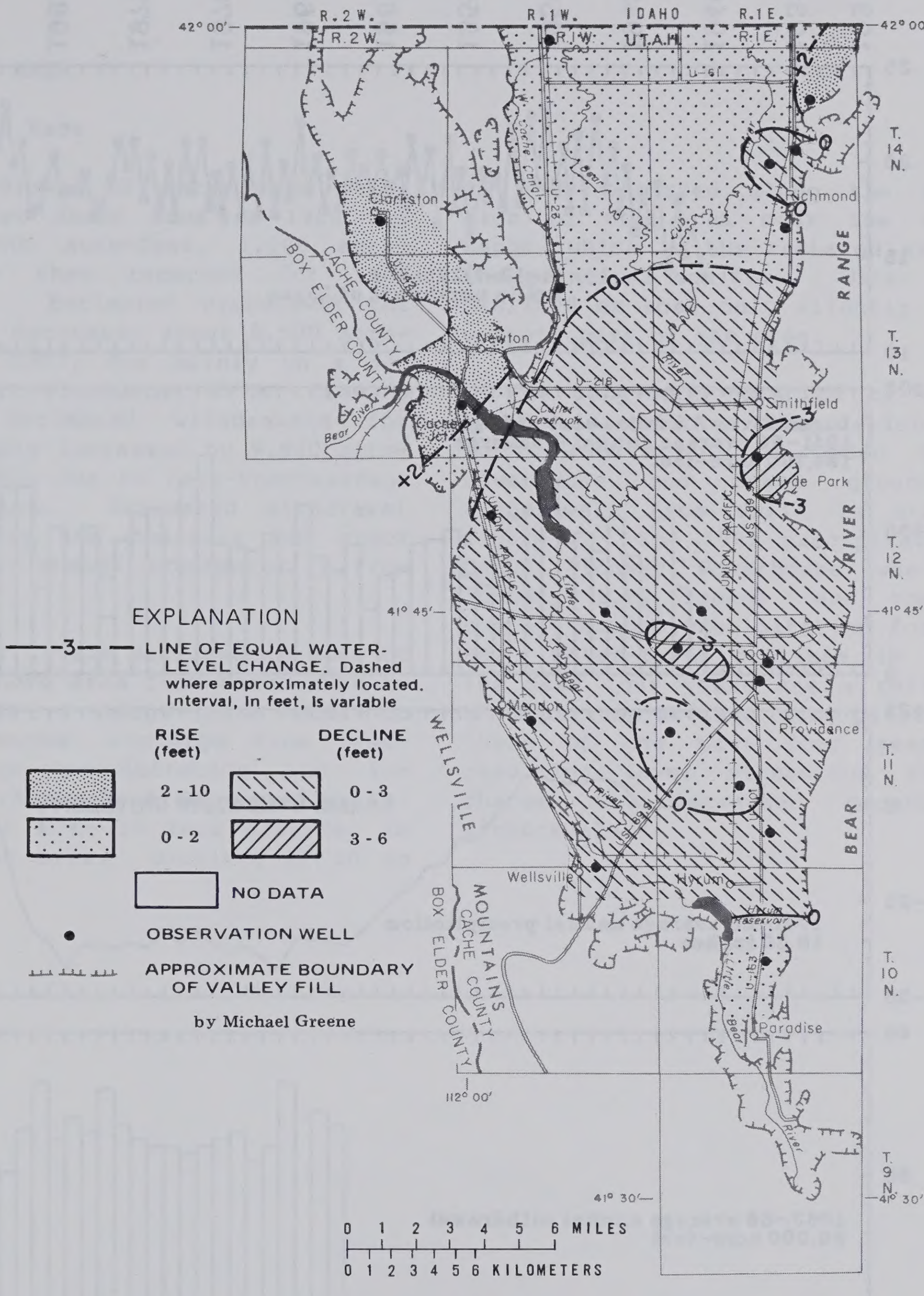


Figure 4--Map of Cache Valley showing change of water levels from March 1988 to March 1989.

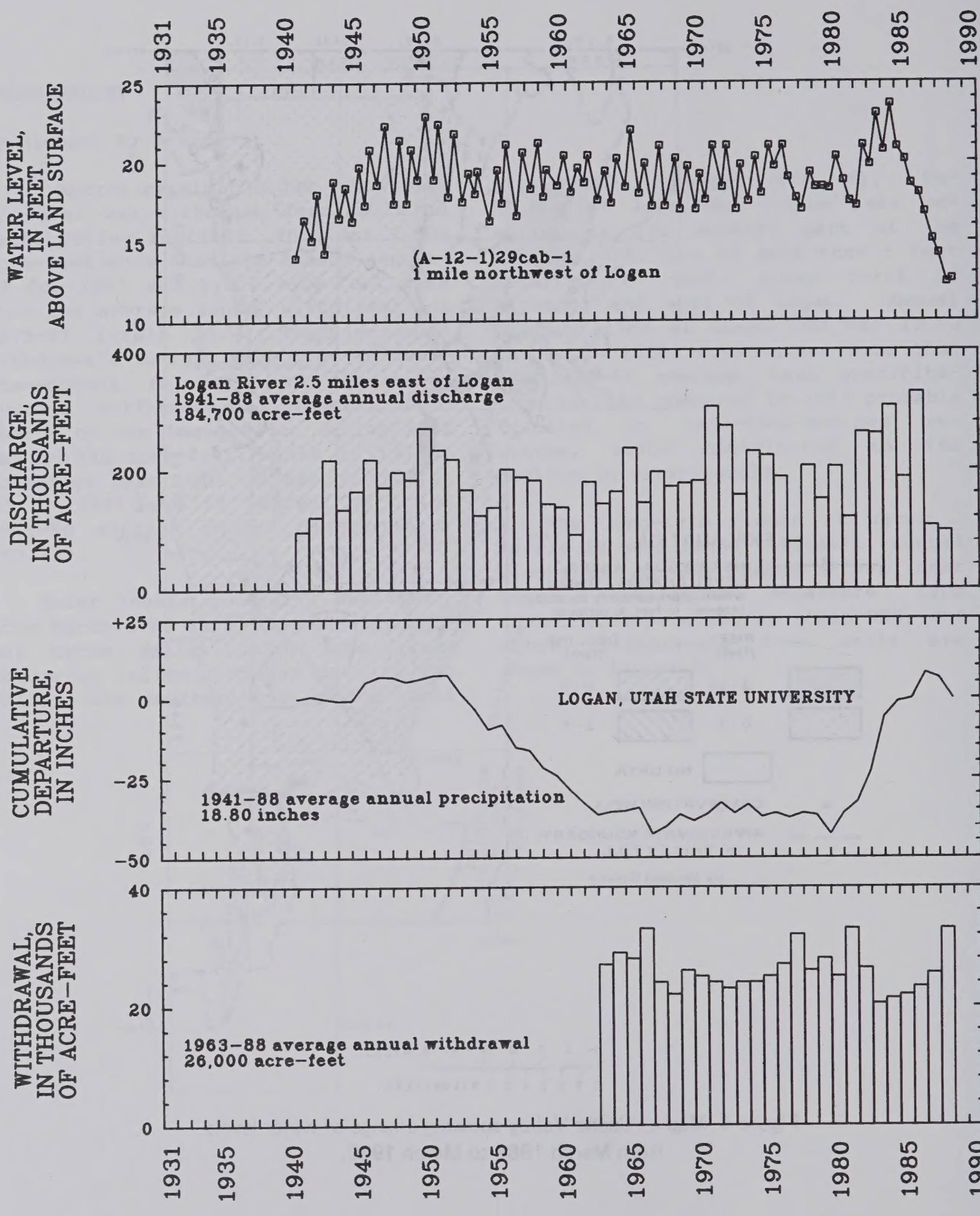


Figure 5.--Relation of water levels in well (A-12-1)29cab-1 in Cache Valley to discharge of the Logan River near Logan, to cumulative departure from the average annual precipitation at Logan, Utah State University, and to annual withdrawals from wells.

EAST SHORE AREA

by James P. Eads

Withdrawal of water from wells in the East Shore area in 1988 was about 68,000 acre-feet, 1,000 acre-feet more than reported for 1987 (table 2). Estimated withdrawal for irrigation decreased about 8,500 acre-feet from 1987, due mainly to a decrease in discharge from flowing wells. Estimated withdrawals for public supply increased by 8,000 acre-feet, largely due to less-than-average precipitation. Estimated withdrawal for industry and domestic and stock use did not change substantially from 1987.

Water levels declined in most of the East Shore area from March 1988 to March 1989 (fig. 6), due to less-than-normal recharge from less-than-average precipitation and increased withdrawals from pumped wells. Declines of 4 to 10 feet occurred in most of the area. Declines of 10 to 25 feet occurred along the eastern side of the area near the Wasatch Range, which is the recharge area for the principal aquifers. Water levels declined or rose only slightly in the western part of the area.

The long-term relation of water levels in selected observation wells to precipitation at Ogden Pioneer Powerhouse and total ground-water withdrawals from wells is shown in figure 7. The 1988 precipitation at Ogden Pioneer Powerhouse was 20.41 inches, 1.29 inches less than the average annual precipitation for 1937-88. Water-level declines in the in the past four years are a reflection of less-than-average precipitation in three of the past four years and resulting lower streamflow and recharge and increased ground-water withdrawals.

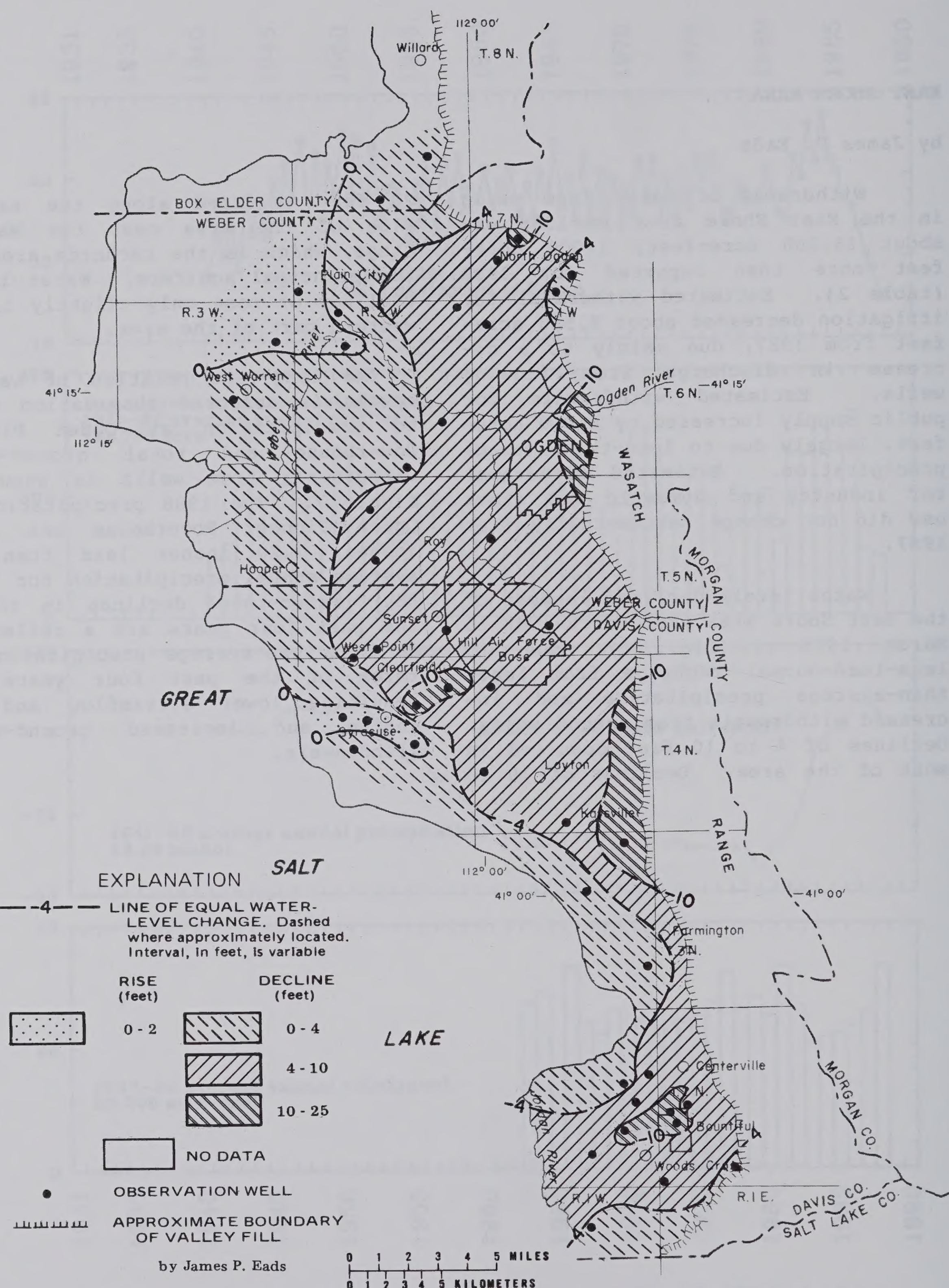


Figure 6.--Map of the East Shore area showing change of water levels from March 1988 to March 1989.

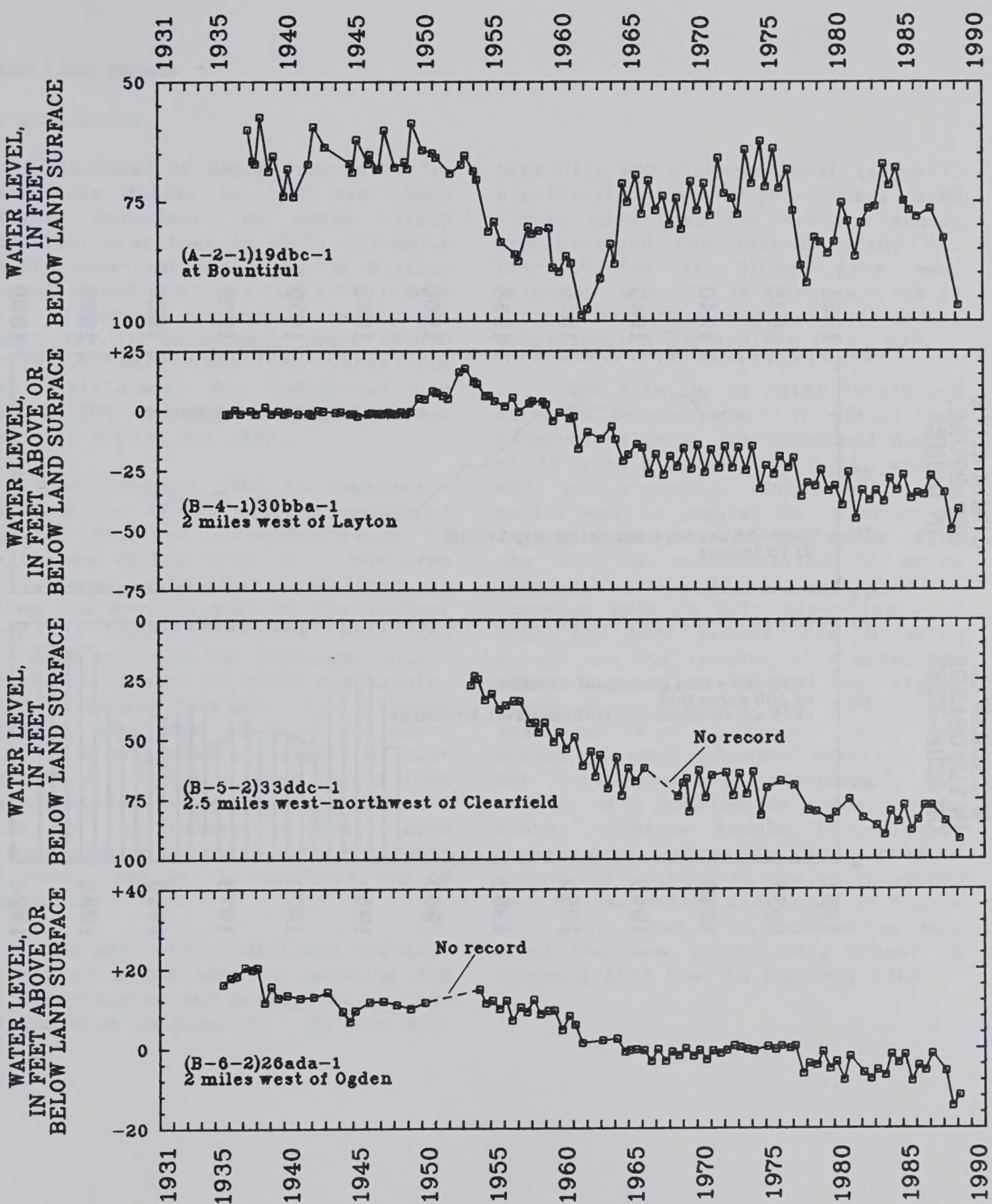


Figure 7.--Relation of water levels in selected wells in the East Shore area to cumulative departure from the average annual precipitation at Ogden Pioneer Powerhouse and to annual withdrawals from wells.

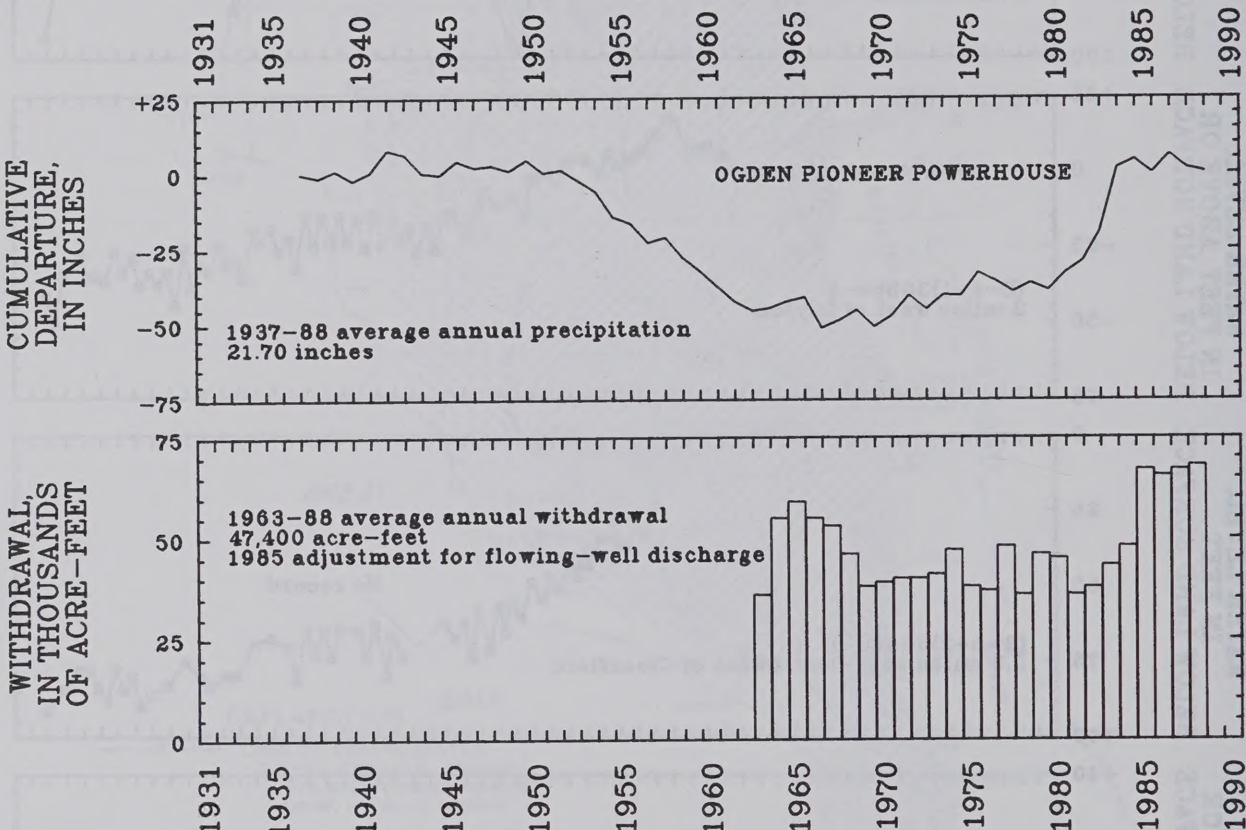


Figure 7.—Continued

SALT LAKE VALLEY

by D.V. Allen

Withdrawal of water from wells in Salt Lake Valley in 1988 was about 141,000 acre-feet, or about 19,000 acre-feet more than in 1987, and about 25,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). Withdrawal for public supply was about 101,000 acre-feet, about 18,000 acre-feet more than the value for 1987. Withdrawal for industrial use was 10,600 acre-feet, slightly less than the amount for 1987.

From February 1988 to February 1989, water levels in the principal aquifer declined throughout most of Salt Lake Valley (fig. 8). The area of largest water-level declines is along the eastern edge of the valley, much of which coincides with the recharge area for the principal aquifer and to an area in which many municipal wells are located. The greatest decline, more than 12 feet, was measured in a well near the center of Salt Lake City. Rises of less than 1 foot were recorded in wells in the northern part of the valley, a small area around Kearns, a small area southwest of Sandy, and at the southern tip of the valley.

The water-level declines are the result of a decrease in recharge due to less-than-normal precipitation, and an increase in pumping. At the Salt Lake City WSO (International Airport), precipitation was 9.29 inches, 5.90 inches less than the average annual precipitation for 1931-88 (fig. 9). Precipitation at Silver Lake near Brighton was 30.68 inches, 12.12 inches less than the average annual precipitation for 1931-88 (fig. 10).

The relation of water levels and chloride concentration in water from selected wells in the principal aquifer to precipitation, to total annual and public-supply withdrawals from wells, and to population is shown in figures 9 and 10. In September 1988, the chloride concentration in water from well (D-1-1)7abd-6 (located in Artesian Park in Salt Lake City, and used by many people for drinking water) was the largest ever measured, 130 milligrams per liter. The largest previous measurement was 120 milligrams per liter in August 1987. The source of the increased chloride has not been definitely identified, but may be salt applied to roads in the winter. Water levels in selected observation wells in the shallow unconfined aquifer in the northwestern part of the valley are shown in figure 11. Water levels in these wells were about the same or slightly higher in February 1989 than in February 1988.

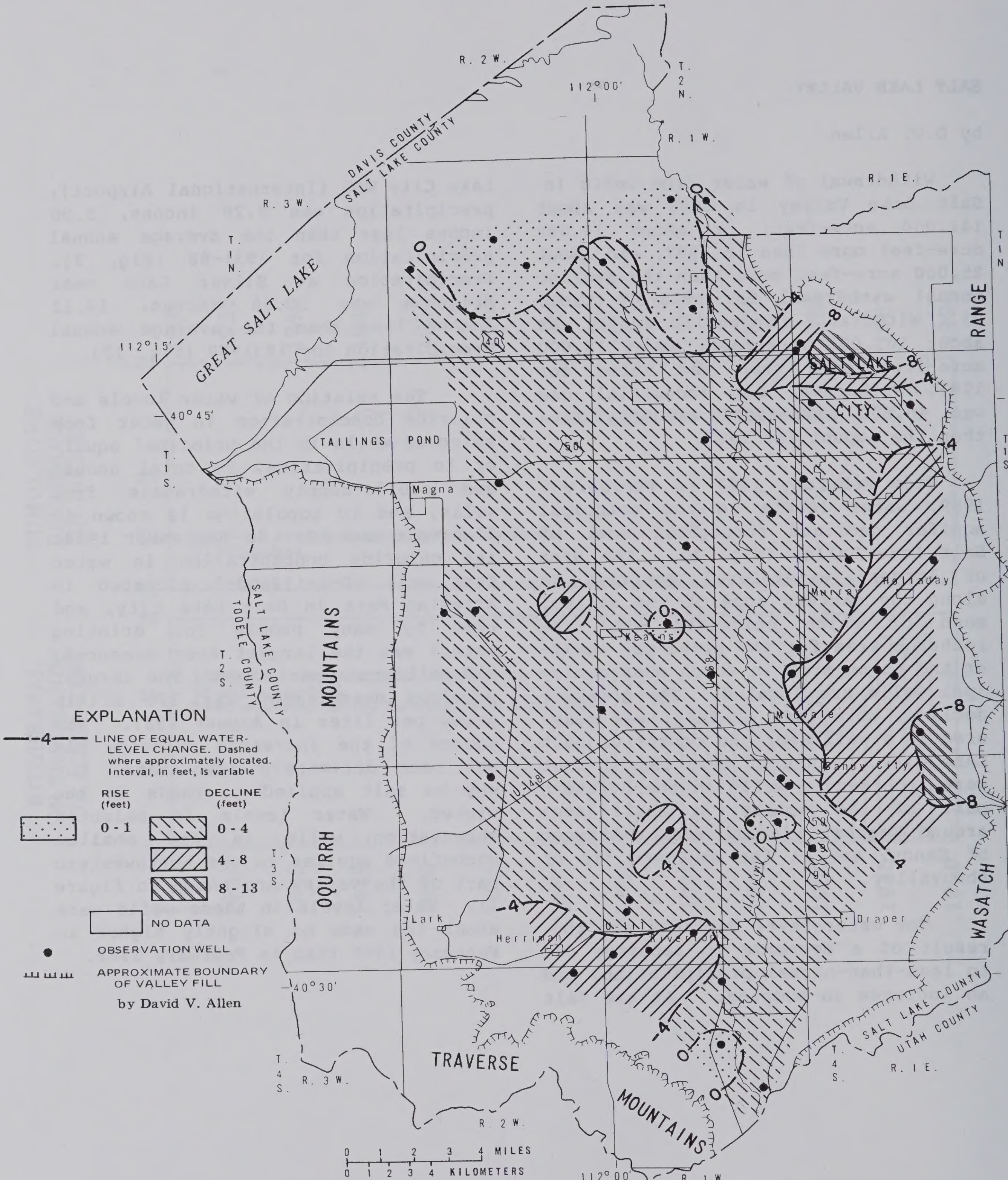


Figure 8.--Map of the Salt Lake Valley showing change of water levels in the principal aquifer from February 1988 to February 1989.

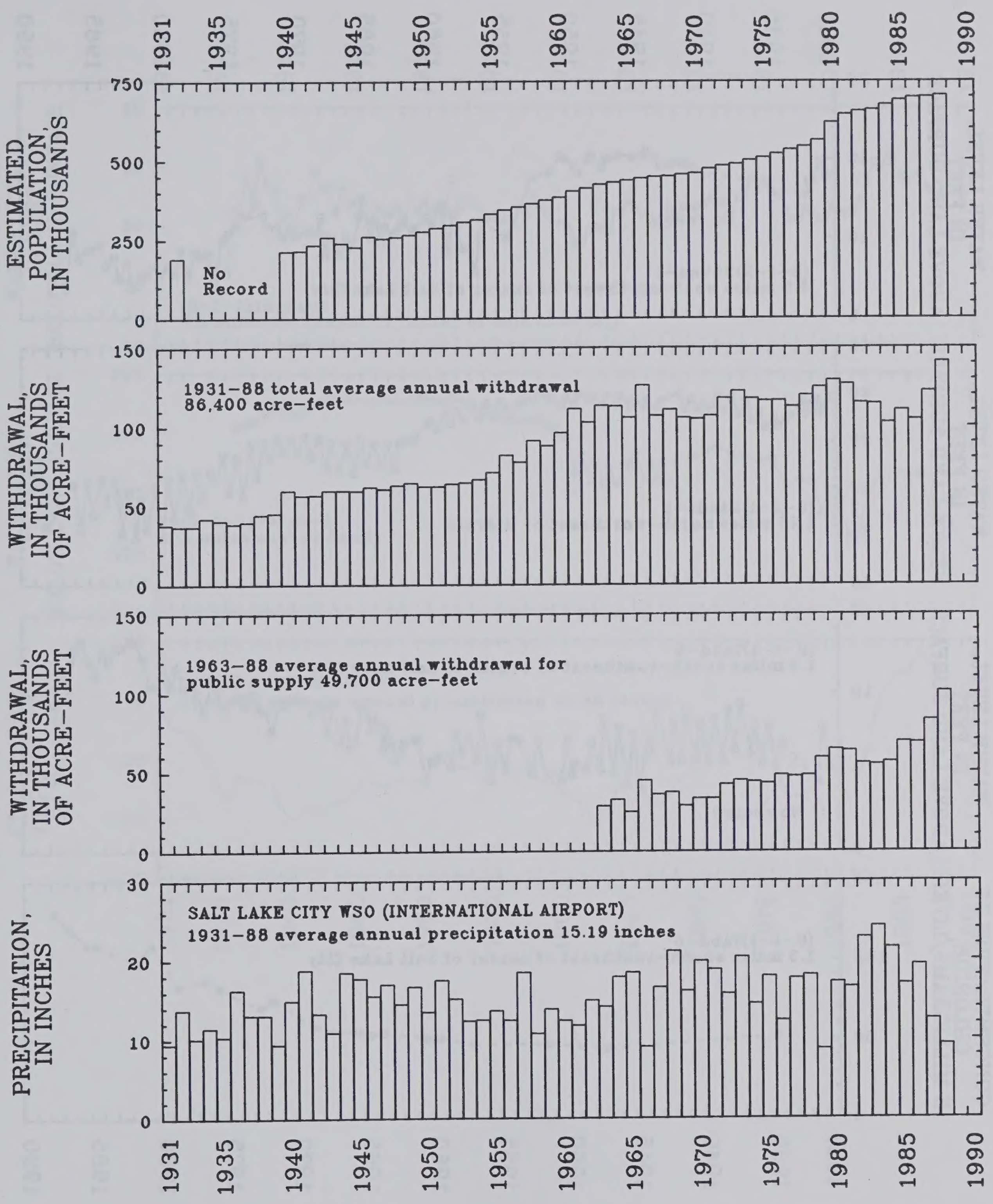


Figure 9.--Estimated population of Salt Lake County, total annual withdrawals from wells, annual withdrawal for public supply, and average annual precipitation at Salt Lake City WSO (International Airport).

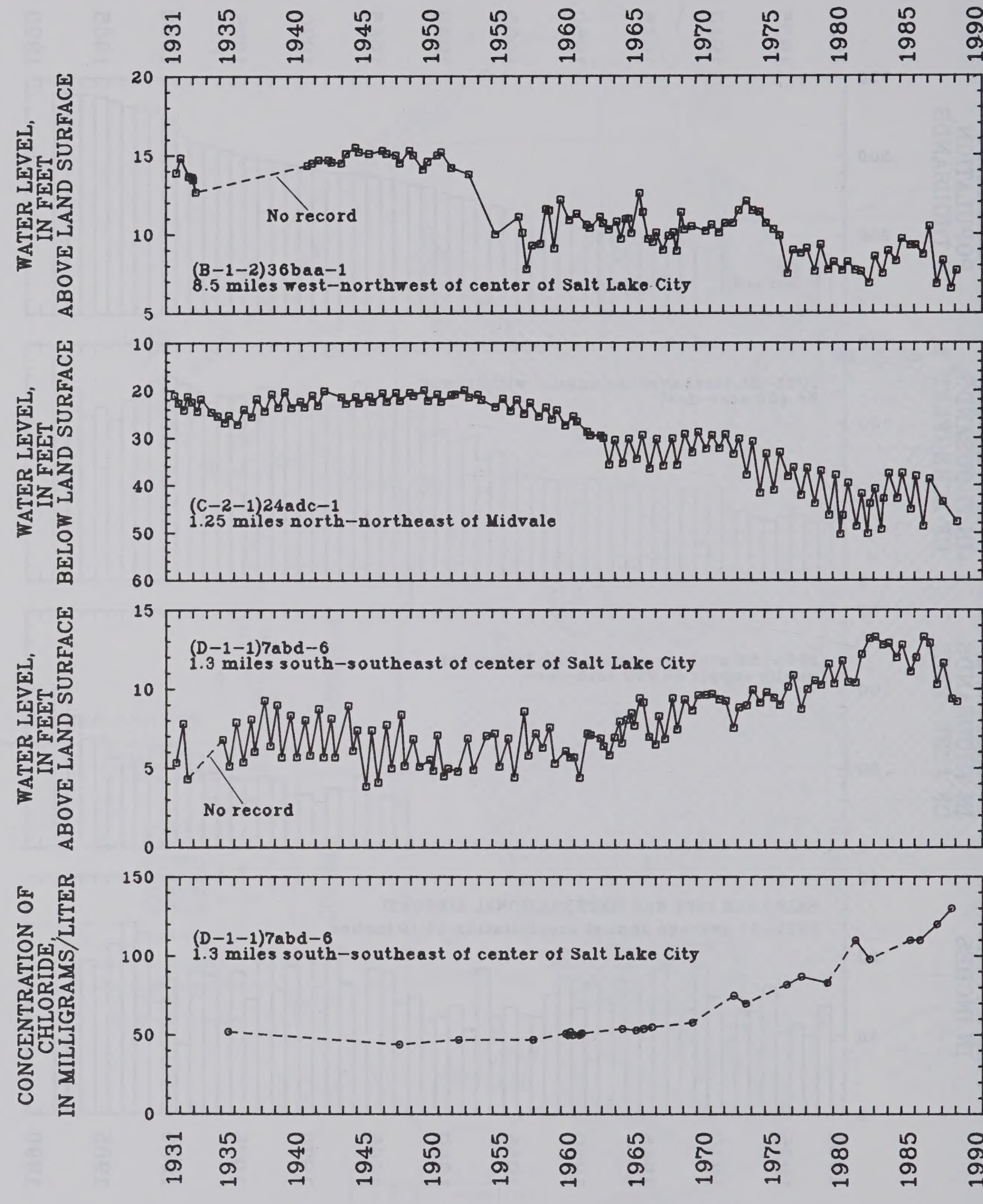


Figure 10.--Relation of water levels and chloride concentration in water from selected wells in the principal aquifer in Salt Lake Valley to cumulative departure from the average annual precipitation at Silver Lake Brighton.

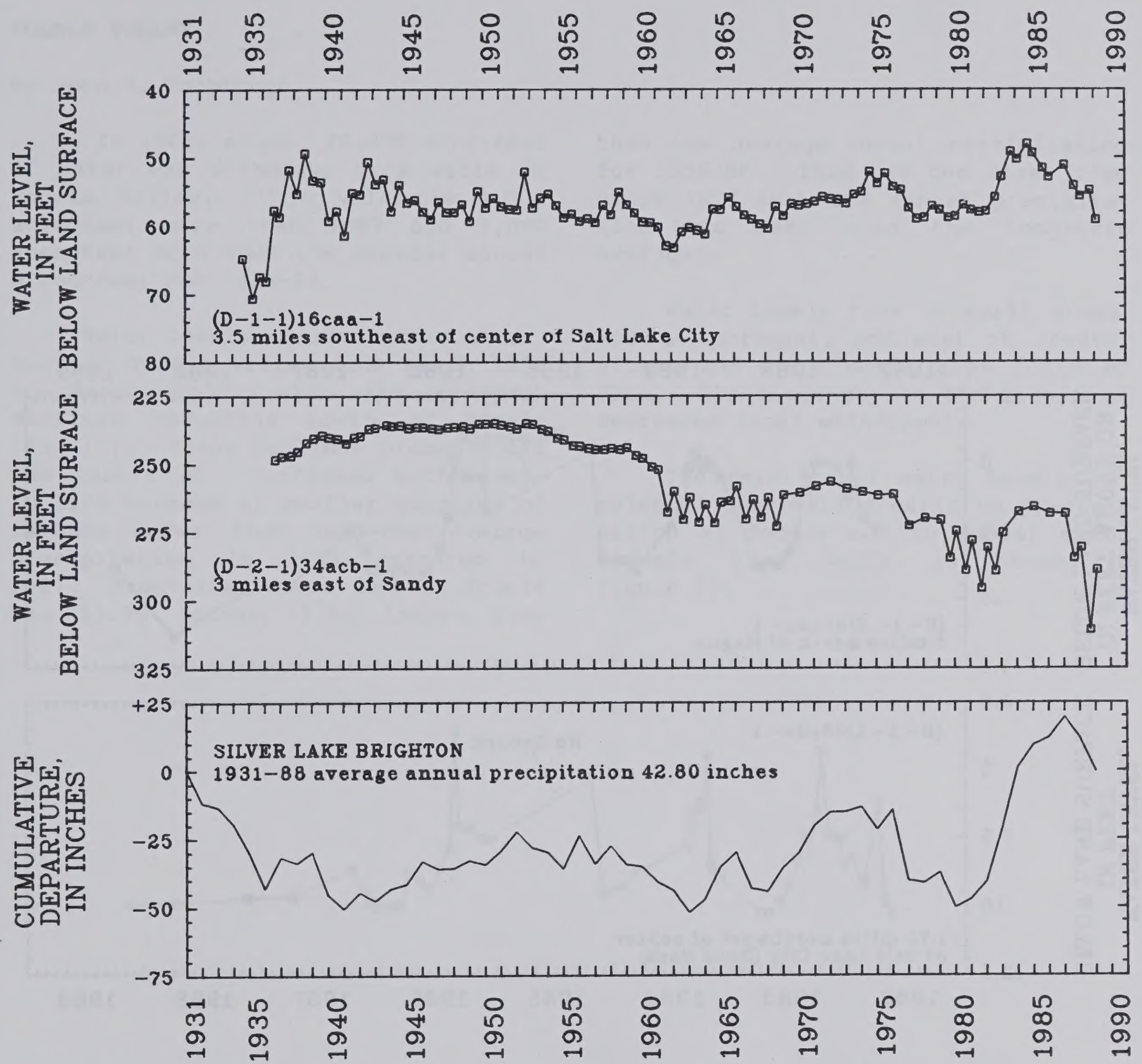


Figure 10.--Continued

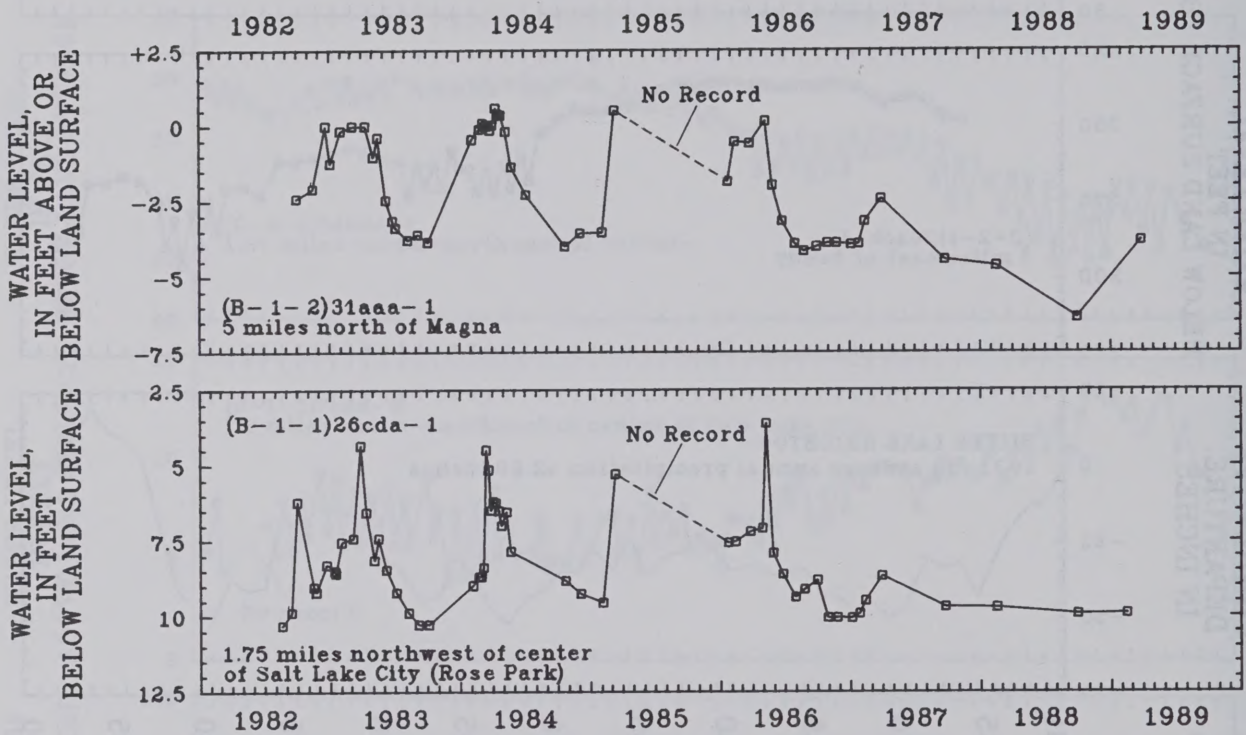


Figure 11.--Water levels in selected wells in the shallow unconfined aquifer in Salt Lake Valley.

TOOELE VALLEY

by John A. Yarbrough

In 1988, about 26,000 acre-feet of water was withdrawn from wells in Tooele Valley. This value is 4,000 acre-feet more than 1987 and 1,000 acre-feet more than the average annual withdrawal for 1978-87.

Water levels declined throughout most of Tooele Valley from March 1988 to March 1989, with the greatest declines occurring north of Tooele (fig 12). These declines probably are the result of increased withdrawals in 1988 because of smaller supplies of surface water from less-than-average precipitation in 1988 compared to 1987. Precipitation in 1988 at Tooele was 15.70 inches, 1.66 inches less than the average annual precipitation for 1936-88. This was the first time since 1979 that the annual precipitation was less than the long-term average.

Water levels rose in small areas north, northeast, and east of Grantsville, and in a small area north of Erda. The rises may be the result of decreased local withdrawals.

The relation of water levels in selected observation wells to precipitation at Tooele and to annual withdrawals from wells is shown in figure 13.

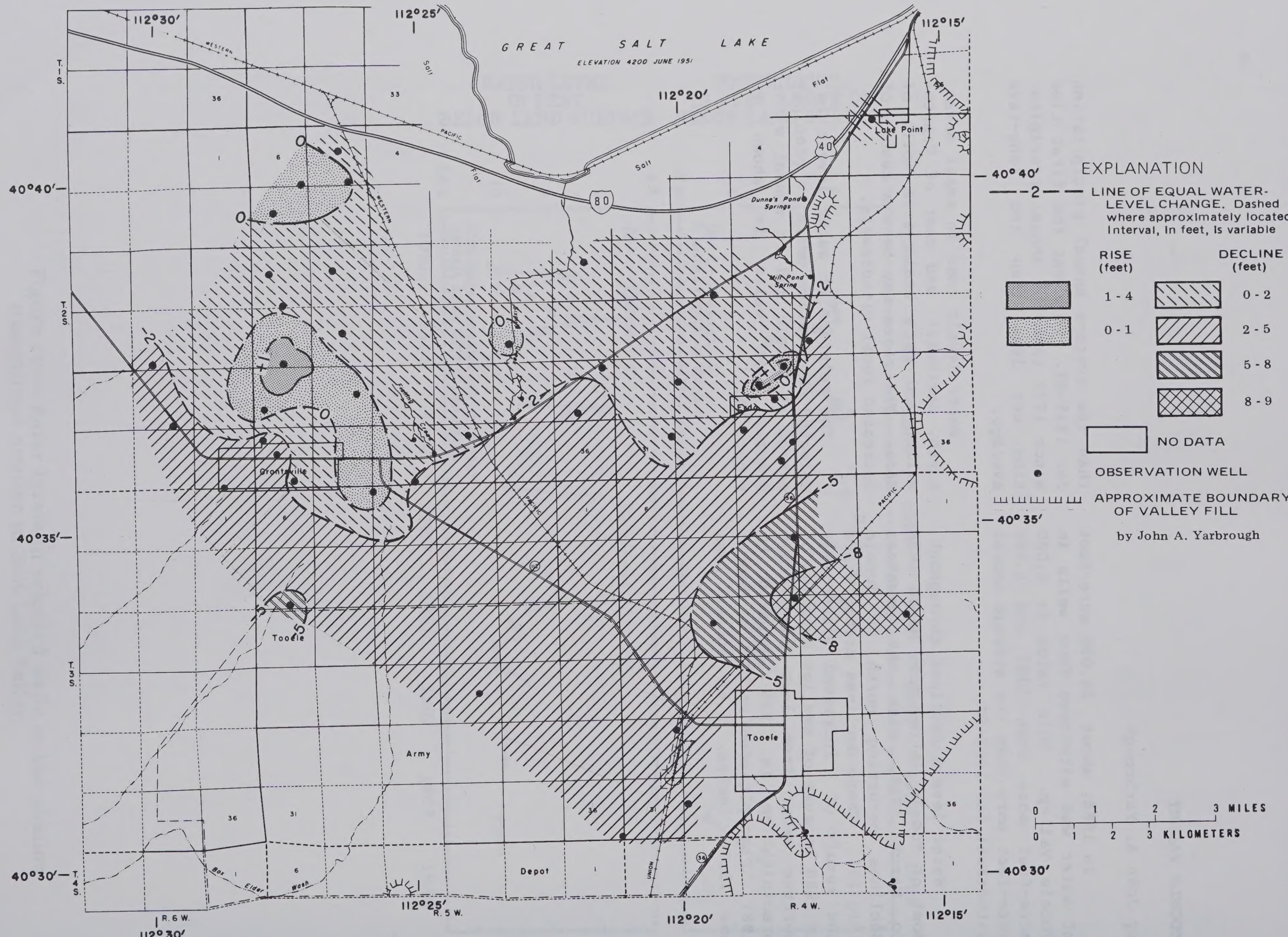


Figure 12.--Map of Tooele Valley showing change of water levels in artesian aquifers from March 1988 to March 1989.

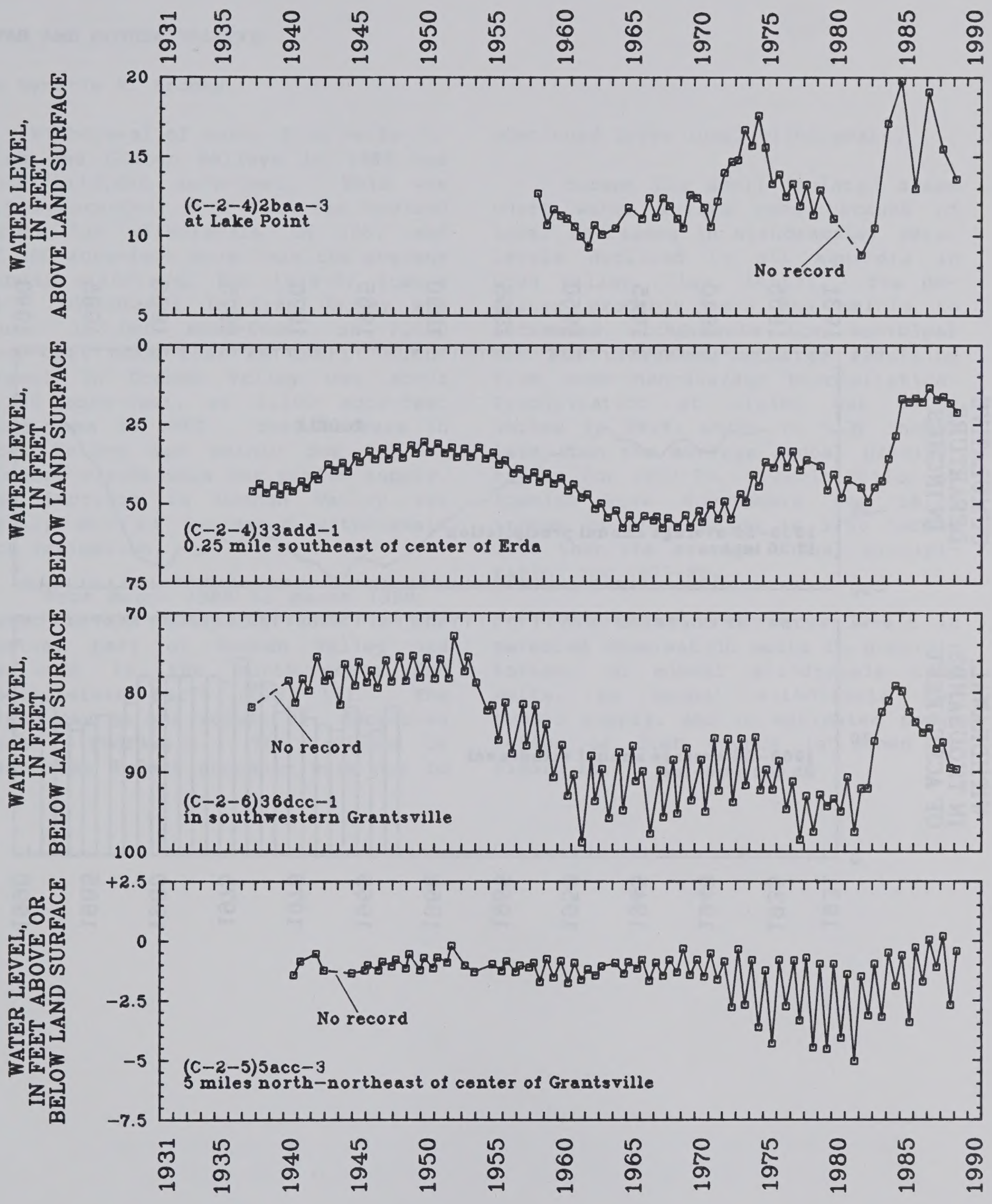


Figure 13.--Relation of water levels in selected wells in Tooele Valley to cumulative departure from the average annual precipitation at Tooele and to annual withdrawals from wells.

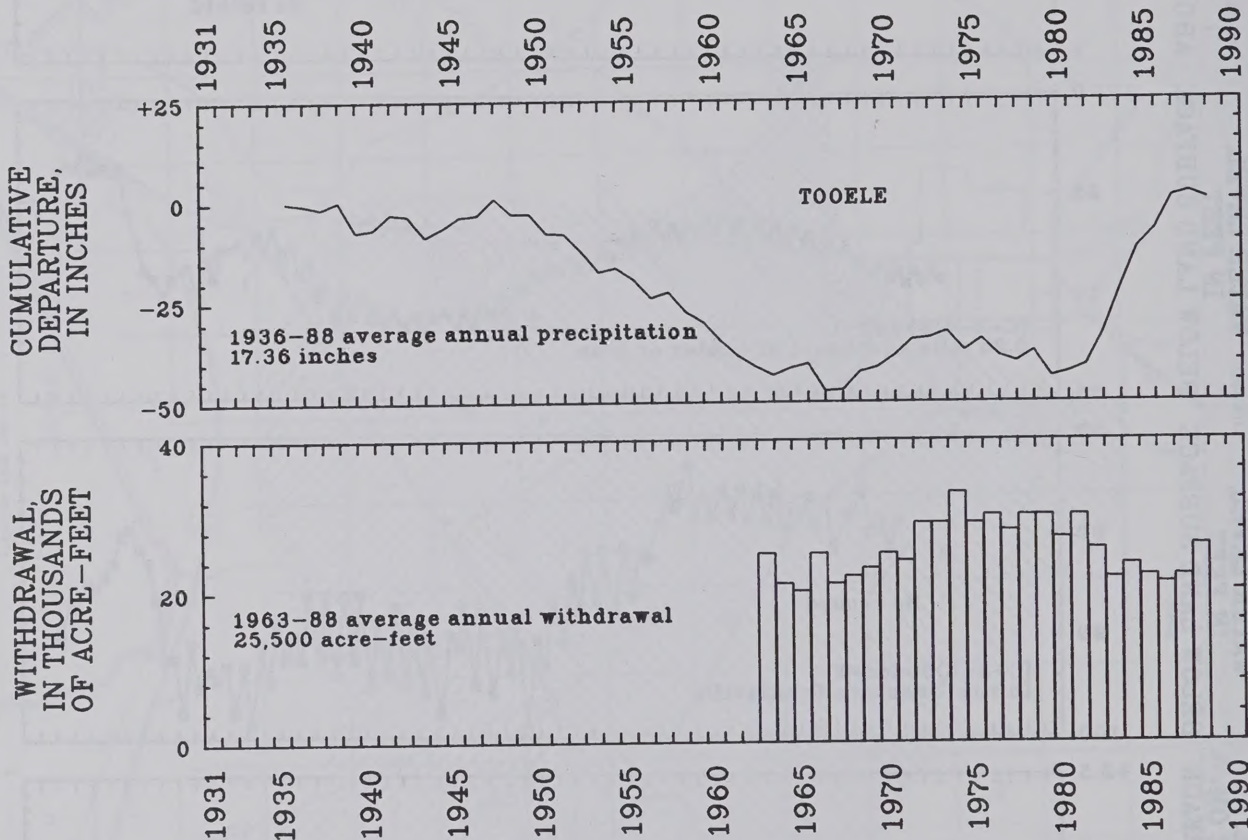


Figure 13.—–Continued

UTAH AND GOSHEN VALLEYS

by Lynette E. Brooks

Withdrawal of water from wells in Utah and Goshen Valleys in 1988 was about 113,000 acre-feet. This was 9,000 acre-feet more than the revised value for withdrawals in 1987 and 22,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). Withdrawal in Utah Valley was about 103,800 acre-feet, or 7,500 acre-feet more than in 1987. Withdrawal in Goshen Valley was about 9,200 acre-feet, or 2,100 acre-feet more than in 1987. The increase in Utah Valley was mainly due to increased withdrawals for public supply. The increase in Goshen Valley was mainly due to increased withdrawals for irrigation.

From March 1988 to March 1989, water levels generally rose in the central part of Goshen Valley and declined in the northwestern and southeastern parts (fig. 14). The rises may be the result of decreased local withdrawals. The declines of less than 2 feet probably were due to continued large local withdrawals.

Except for small isolated areas where water levels rose because of local decreases in withdrawals, water levels declined in all aquifers in Utah Valley (figs. 14-17). The declines probably were due mainly to increased withdrawals for municipal use and decreased recharge resulting from less-than-average precipitation. Precipitation at Alpine was 10.83 inches in 1988, which is 5.32 inches less than the average annual precipitation for 1937-88. Precipitation at Spanish Fork Powerhouse was 16.24 inches in 1988, which is 3.00 inches less than the average annual precipitation for 1937-88.

The relation of water levels in selected observation wells to precipitation, to annual withdrawals from wells, to annual withdrawals for public supply, and to estimated population of Utah County is shown in figure 18.

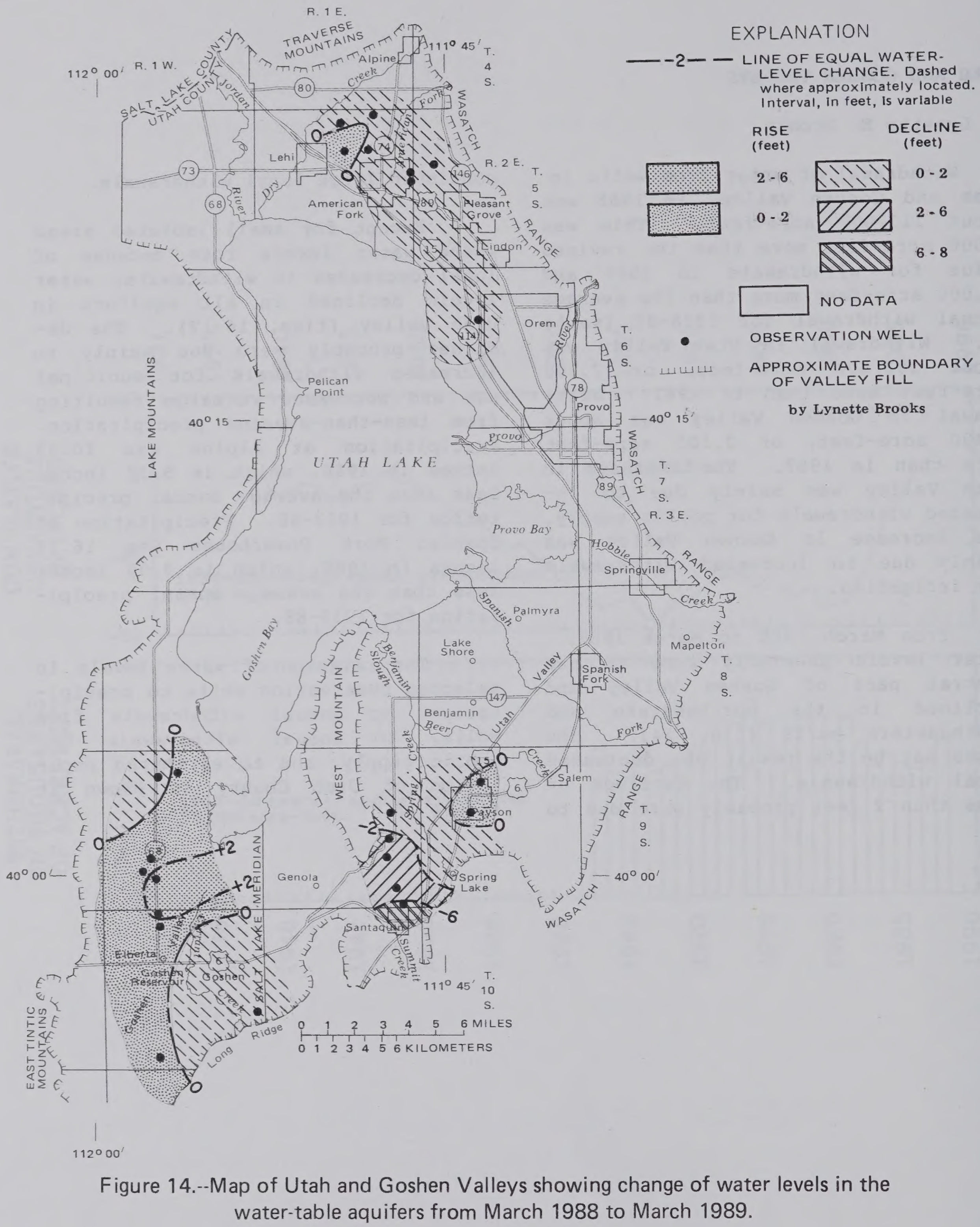


Figure 14.--Map of Utah and Goshen Valleys showing change of water levels in the water-table aquifers from March 1988 to March 1989.

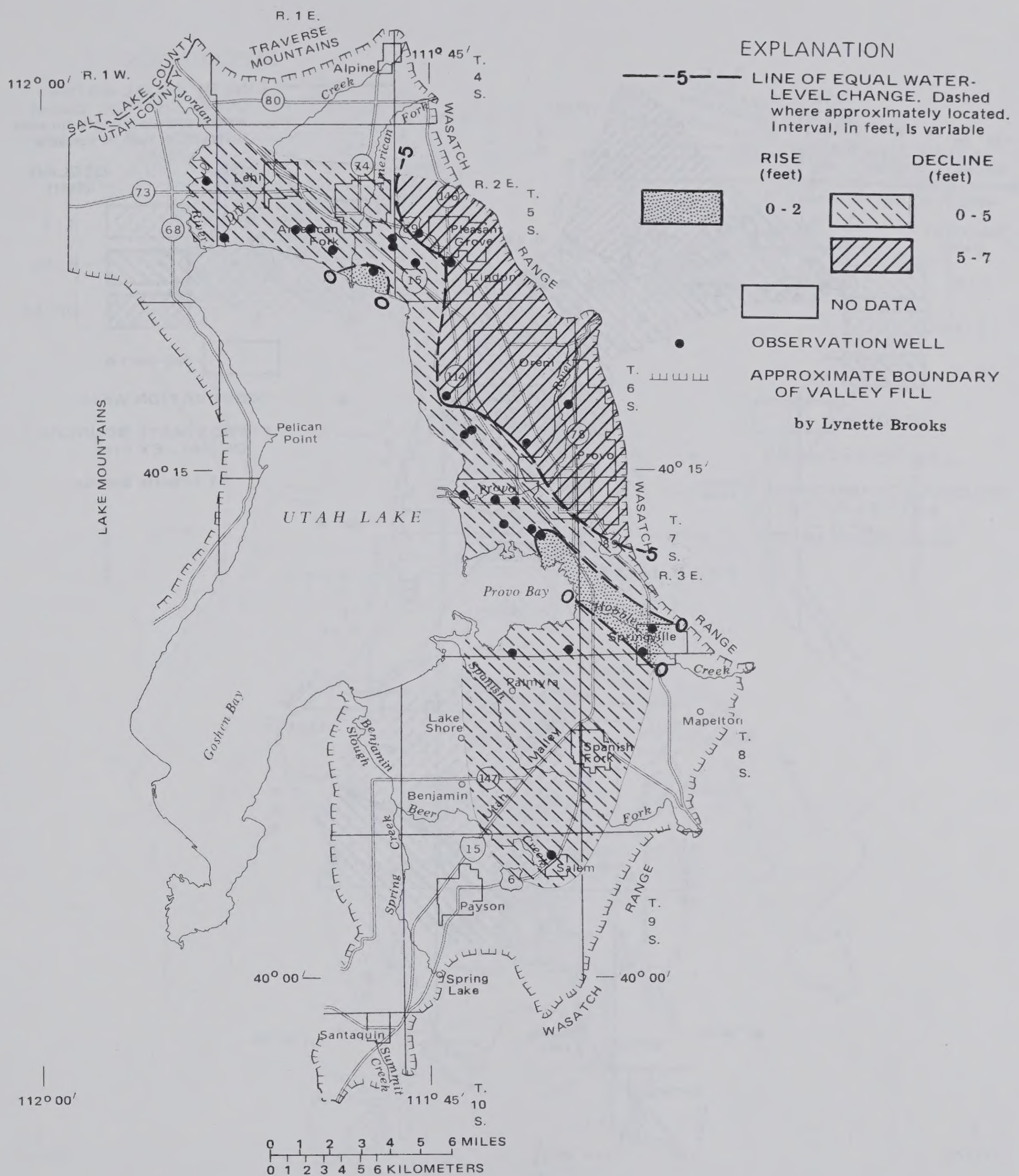


Figure 15.--Map of Utah Valley showing change of water levels in the shallow artesian aquifer in deposits of Pleistocene age from March 1988 to March 1989.

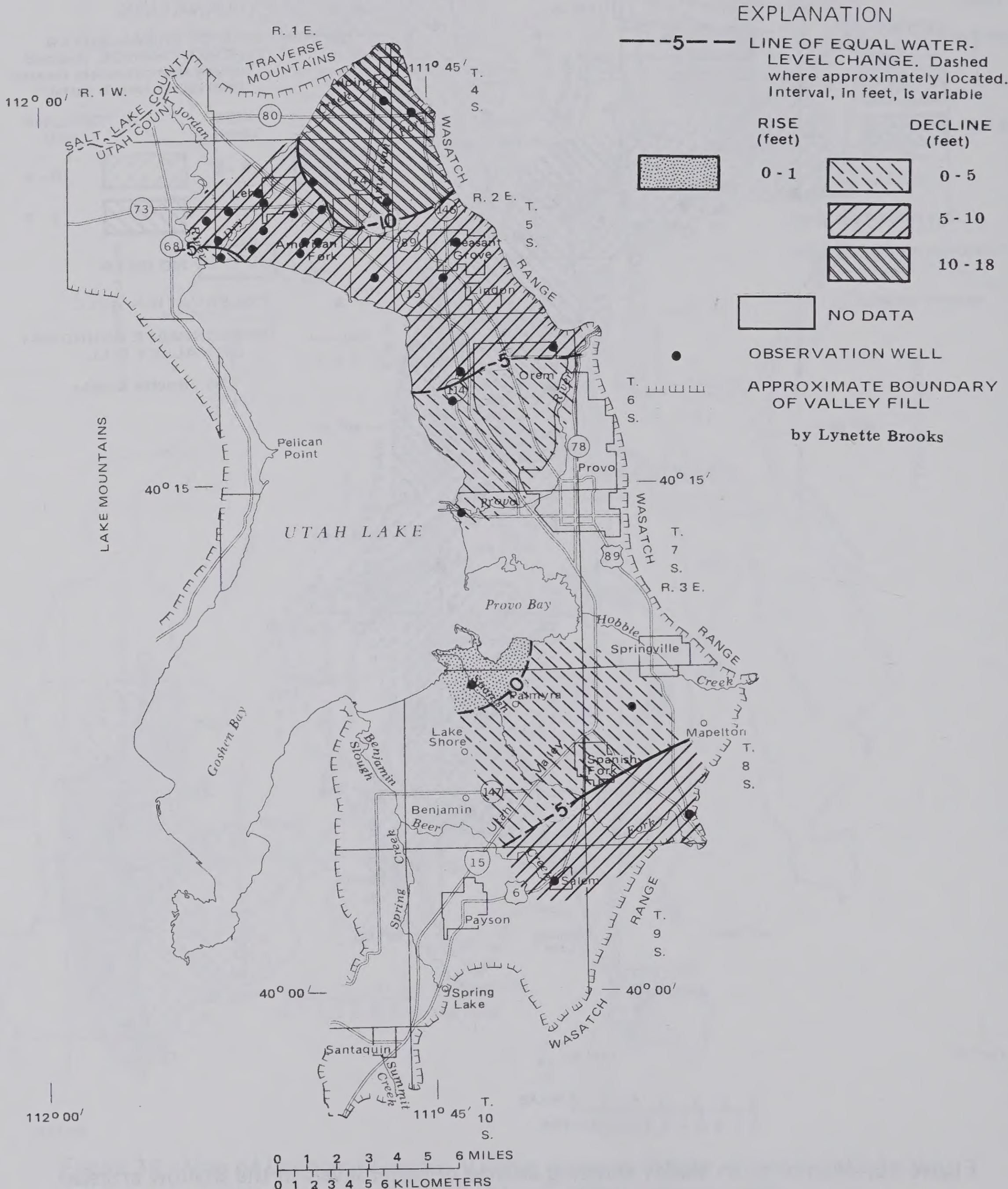


Figure 16.--Map of Utah Valley showing change of water levels in the deep artesian aquifer in deposits of Pleistocene age from March 1988 to March 1989.

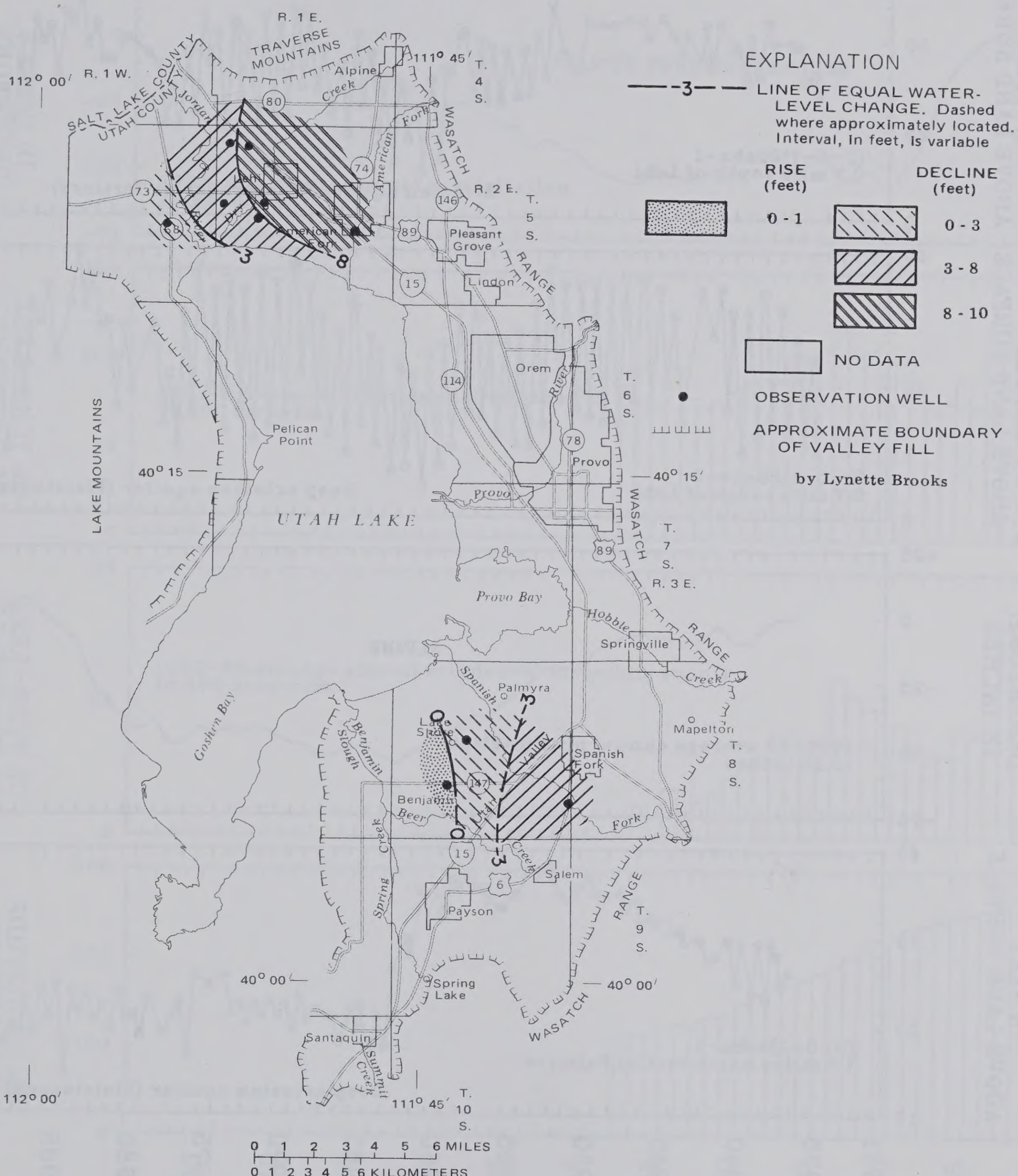


Figure 17.--Map of Utah Valley showing change of water levels in the artesian aquifer in deposits of Quaternary or Tertiary age from March 1988 to March 1989.

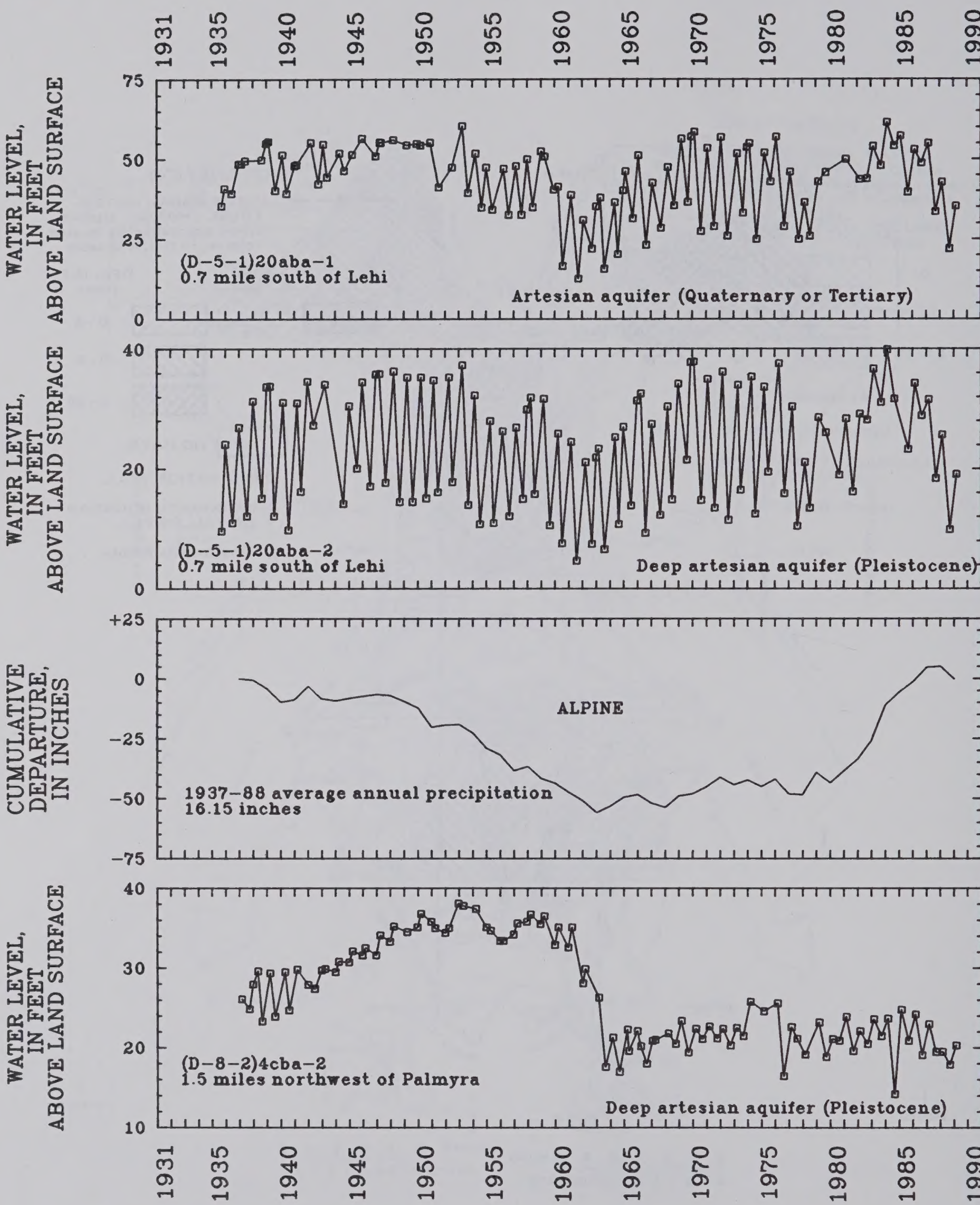


Figure 18.--Relation of water levels in selected wells to cumulative departure from the average annual precipitation at Alpine and Spanish Fork Powerhouse, to total annual withdrawals from wells and annual withdrawals for public supply in Utah and Goshen Valleys, and to estimated population of Utah County.

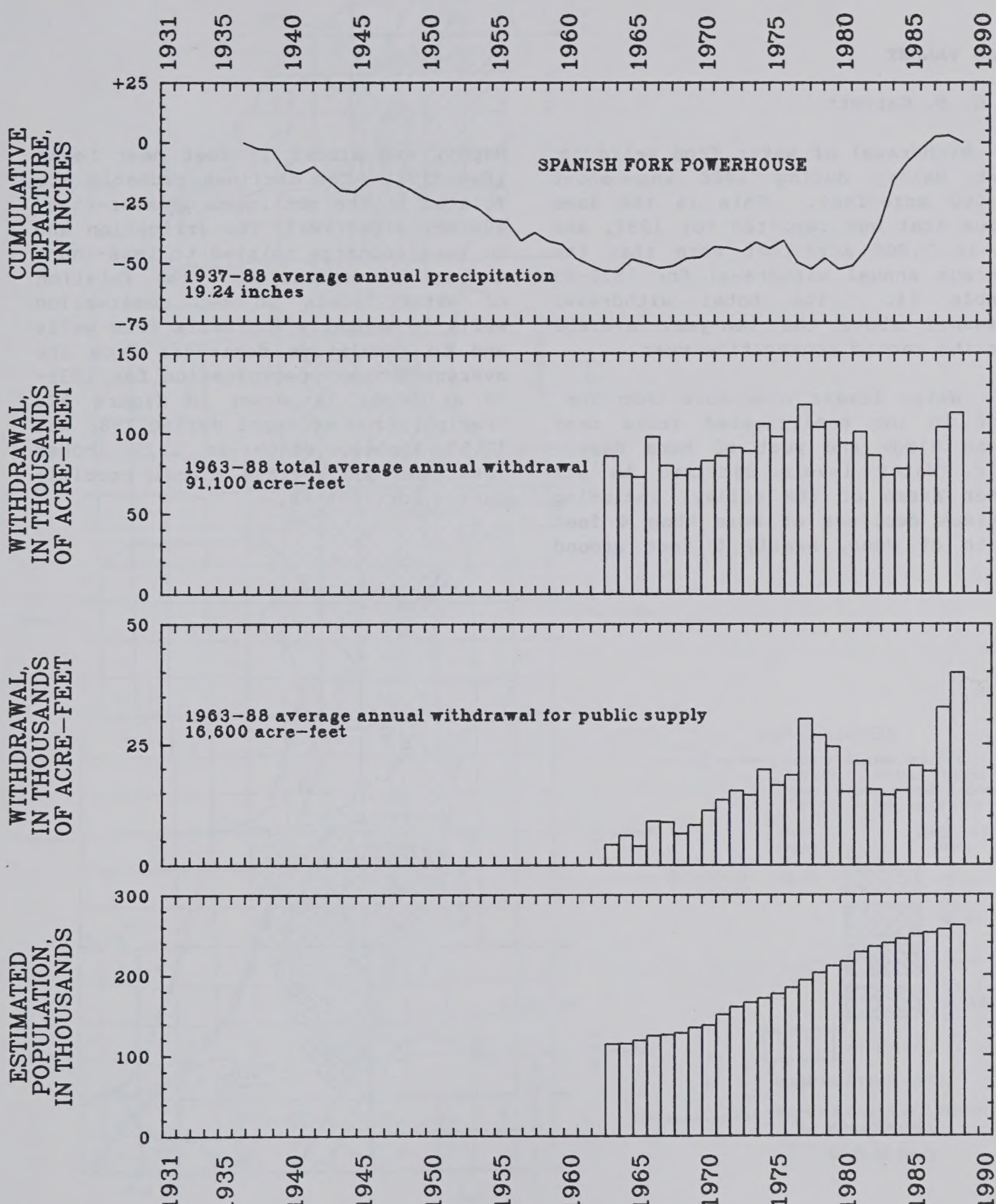


Figure 18.—Continued

JUAB VALLEY

by R. B. Garrett

Withdrawal of water from wells in Juab Valley during 1988 was about 22,000 acre-feet. This is the same value that was reported for 1987, and it is 7,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). The total withdrawal remained above the ten-year average for the second consecutive year.

Water levels rose more than one foot in the nonirrigated areas near Levan Ridge and west of Mona Reservoir. Water levels declined in all other areas of the valley, including maximum declines of more than 4 feet north of Mona, nearly 6 feet around Nephi, and almost 12 feet near Levan (fig. 19). The declines probably are related to the continued greater-than-average withdrawals for irrigation and to less recharge related to less-than-average precipitation. The relation of water levels in two observation wells to annual withdrawals from wells and to cumulative departure from the average annual precipitation for 1935-88 at Nephi is shown in figure 20. Precipitation at Nephi during 1988 was 12.53 inches, which is 1.79 inches less than the average annual precipitation for 1935-88.

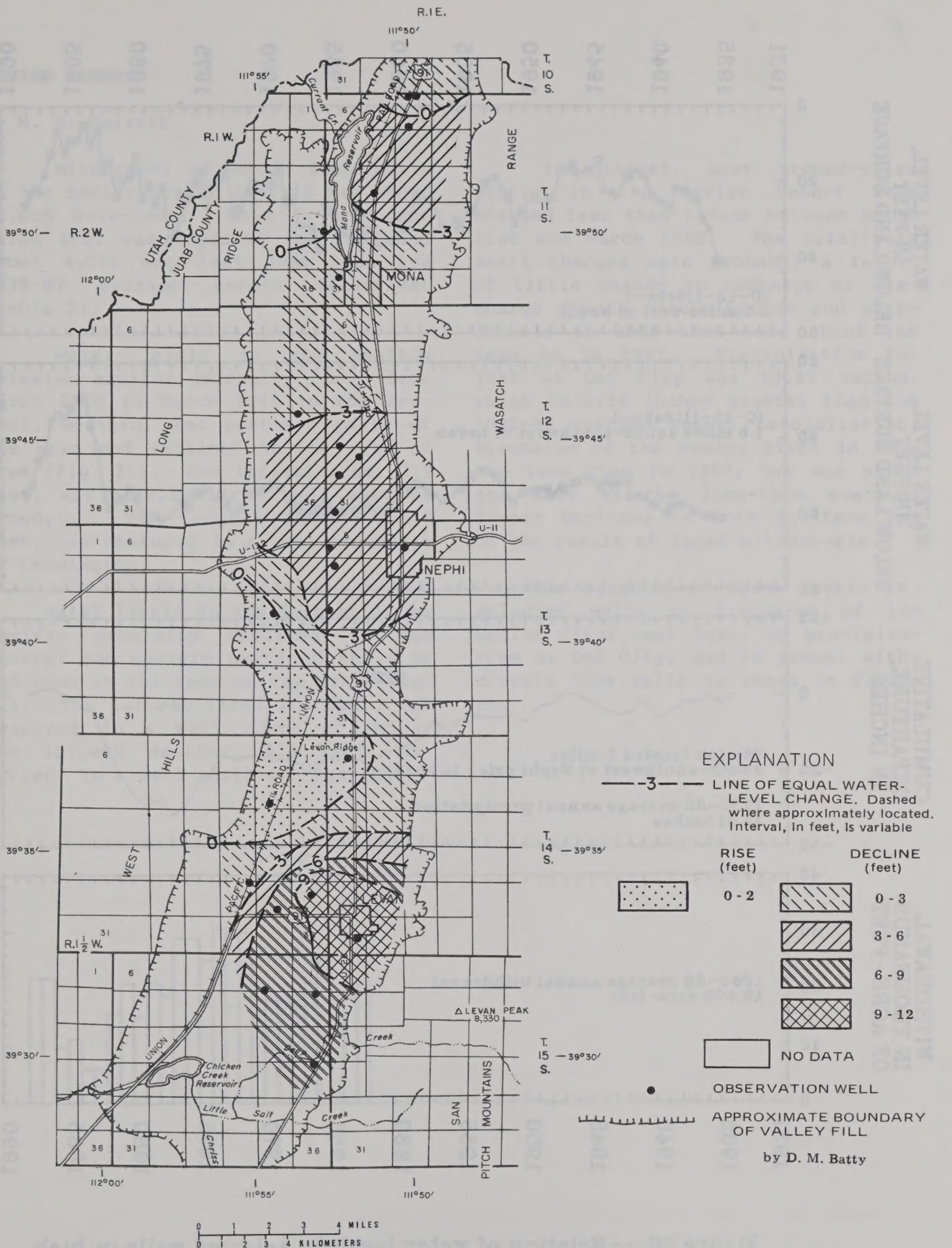


Figure 19.--Map of Juab Valley showing change of water levels from March 1988 to March 1989.

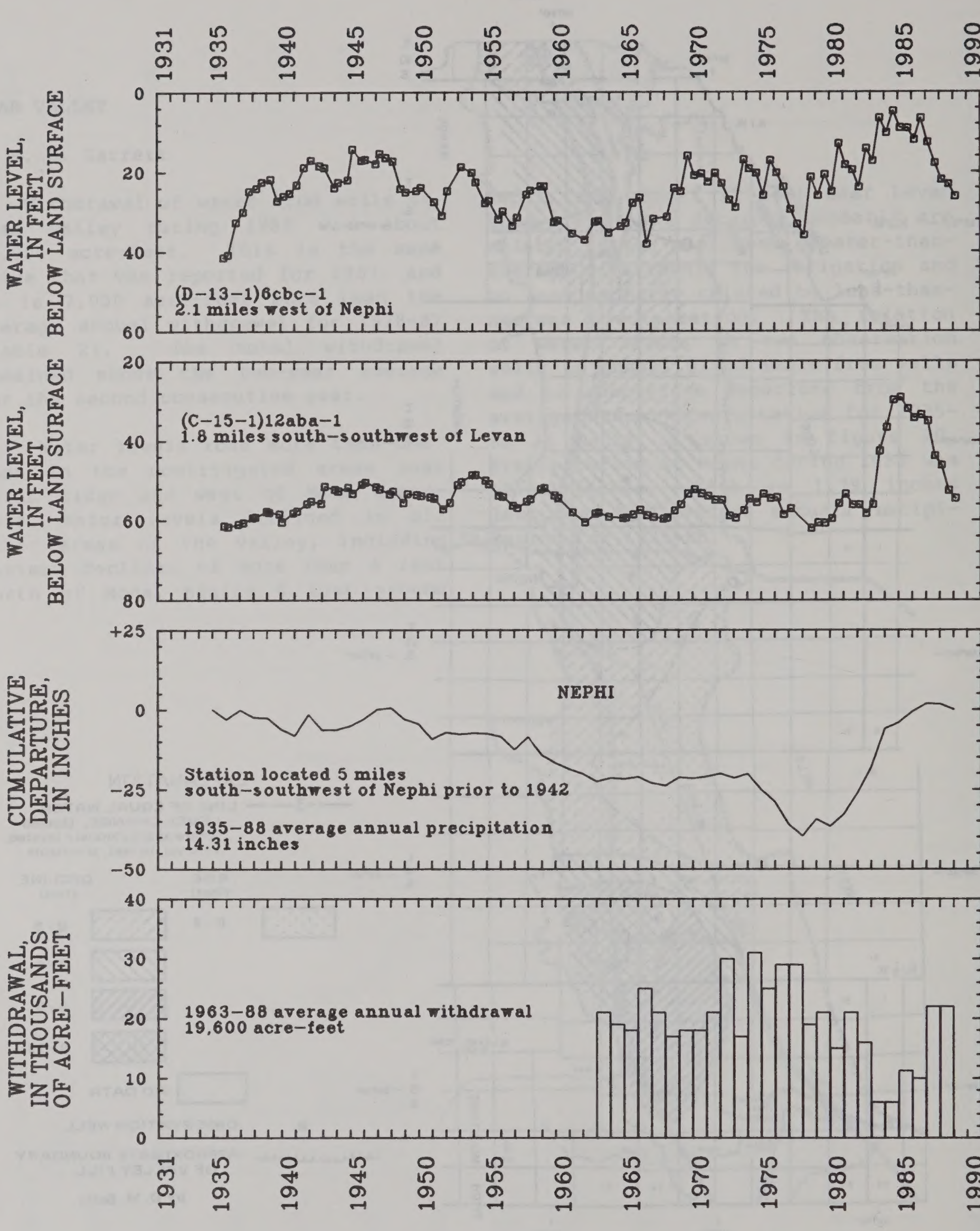


Figure 20.--Relation of water levels in selected wells in Juab Valley to cumulative departure from the average annual precipitation at Nephi and to annual withdrawals from wells.

SEVIER DESERT

by R. B. Garrett

Withdrawal of water from wells in the Sevier Desert in 1988 was about 15,000 acre-feet. This is the same value that was reported for 1987 and about 4,000 acre-feet less than the 1978-87 average annual withdrawal (table 2).

Water levels in the shallow artesian aquifer generally rose from March 1988 to March 1989 in the central, western, and northern parts of the area and declined in the rest of area (fig. 21). The largest rise, 0.3 feet, was measured in a well west of Lynndyl. The largest decline, 8.6 feet, was measured in a well southeast of Leamington.

Water levels in the deep artesian aquifer generally declined in the central and eastern parts of the area and rose in the rest of the area (fig. 22). The largest rise, 2.4 feet, was measured in a well north of Delta. The largest decline, 4.4 feet, occurred in a well north of Oak City.

In general, most ground-water levels in the Sevier Desert area changed less than 1 foot between March 1988 and March 1989. The relatively small changes were probably a result of little change in recharge or discharge due to precipitation and withdrawals in 1988 that were about the same as in 1987. Precipitation for 1988 at Oak City was 13.42 inches, which is 0.54 inches greater than the 1935-88 average annual precipitation. Discharge of the Sevier River in 1988 was less than in 1987, but was about the same as the long-term average. Larger declines in both aquifers may be the result of local withdrawals.

The relation of water levels in selected wells to discharge of the Sevier River near Juab, to precipitation at Oak City, and to annual withdrawals from wells is shown in figure 23.

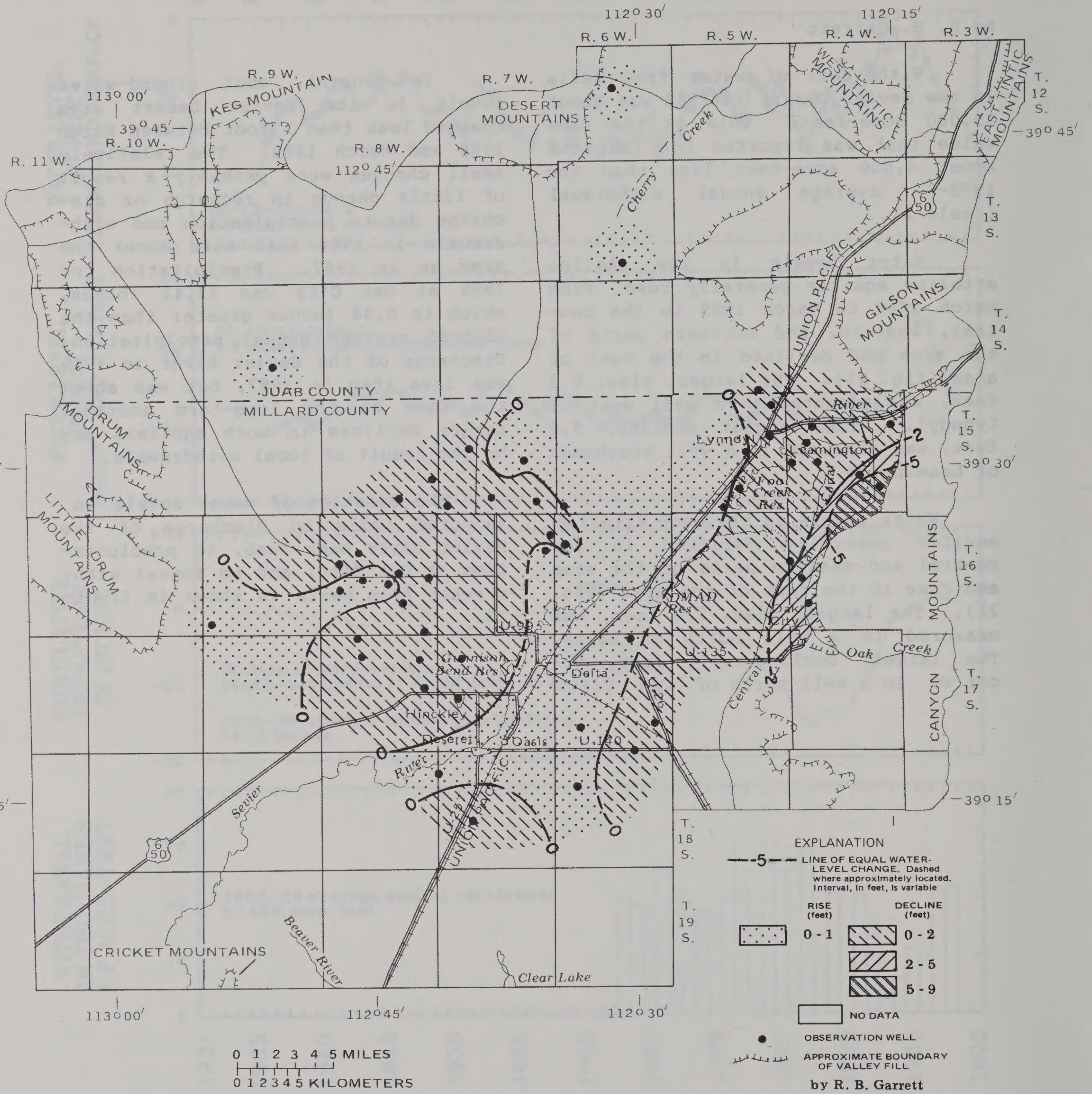


Figure 21.--Map of part of the Sevier Desert showing change of water levels in the shallow artesian aquifer from March 1988 to March 1989.

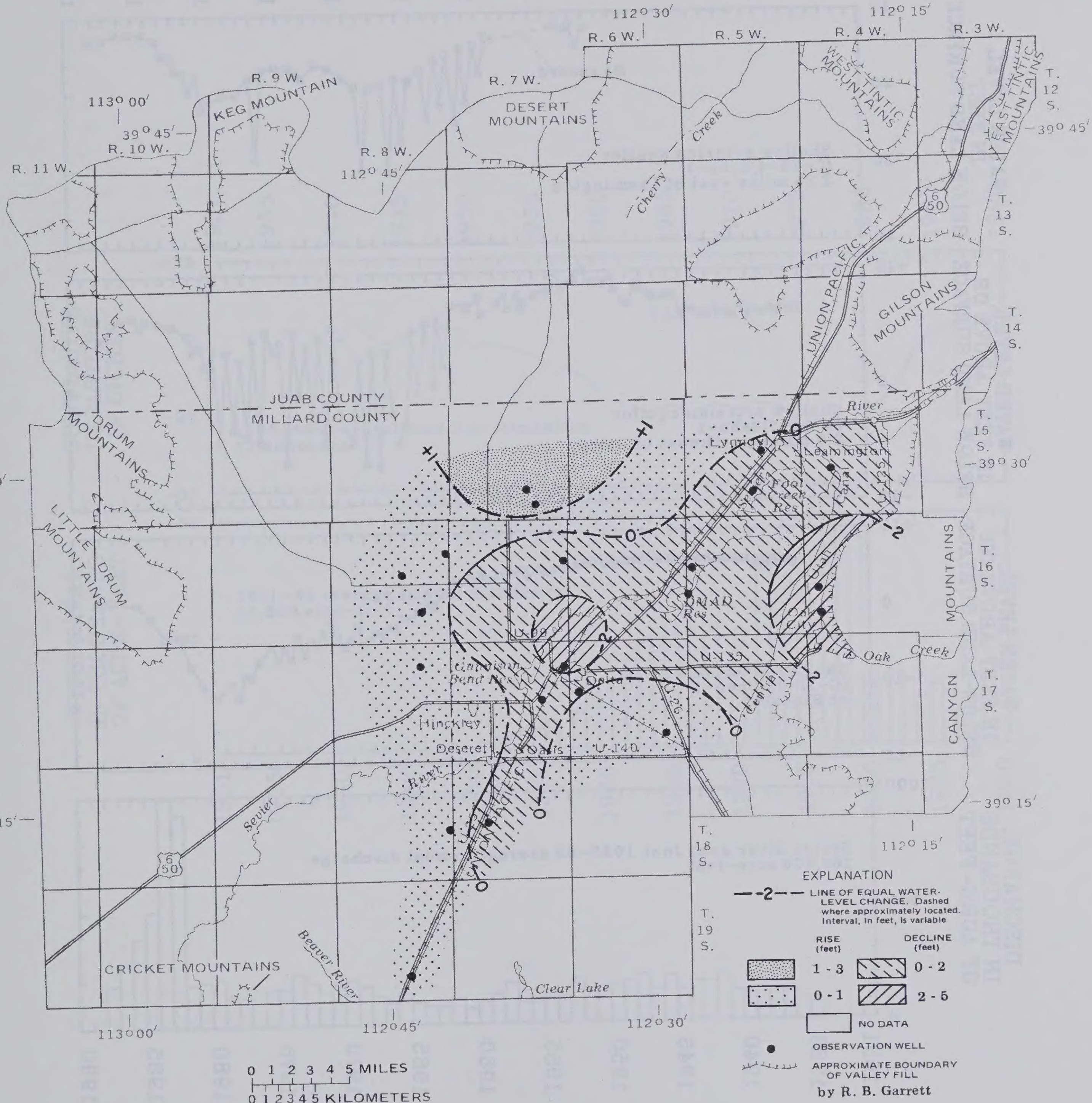


Figure 22.--Map of part of the Sevier Desert showing change of water levels in the deep artesian aquifer from March 1988 to March 1989.

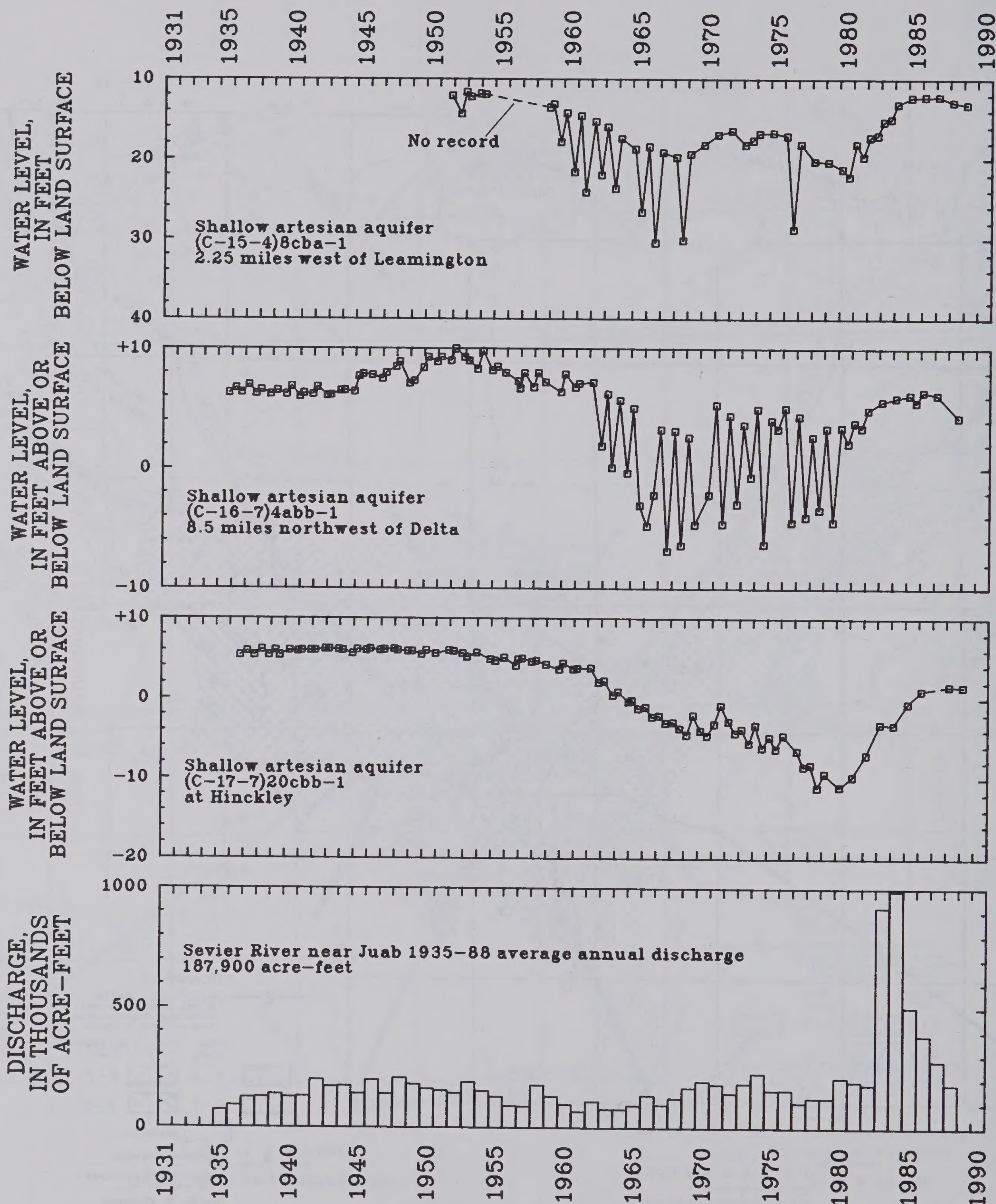


Figure 23.--Relation of water levels in selected wells in the Sevier Desert to discharge of the Sevier River near Juab, to cumulative departure from the average annual precipitation at Oak City, and to annual withdrawals from wells.

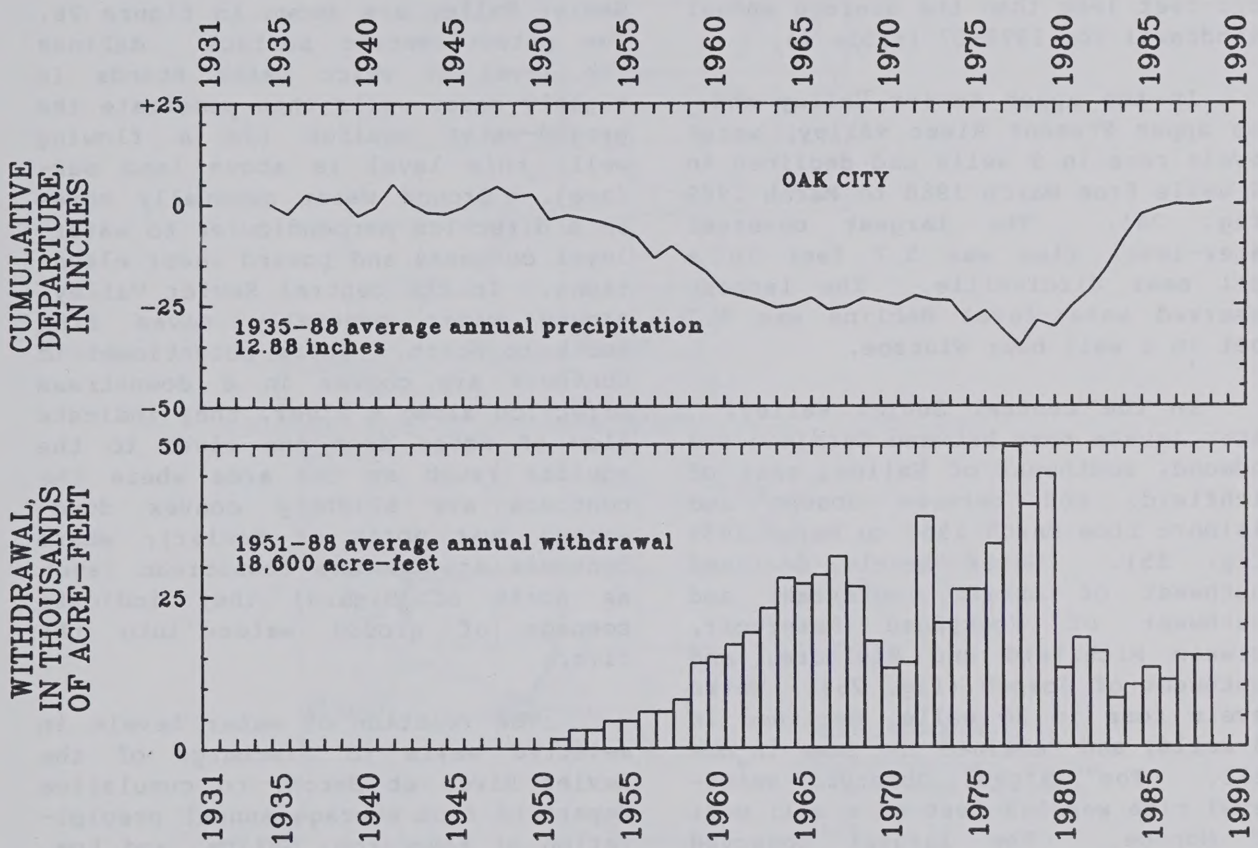


Figure 23.—Continued

UPPER AND CENTRAL SEVIER VALLEYS AND UPPER FREMONT RIVER VALLEY

by W.C. Brothers and R.W. Puchta

Withdrawal of water from wells in the upper and central Sevier Valleys and upper Fremont River valley in 1988 was about 21,000 acre-feet, 1,000 acre-feet less than in 1987, and 2,000 acre-feet less than the average annual withdrawal for 1978-87 (table 2).

In the upper Sevier Valley and the upper Fremont River valley, water levels rose in 9 wells and declined in 10 wells from March 1988 to March 1989 (fig. 24). The largest observed water-level rise was 5.7 feet in a well near Circleville. The largest observed water-level decline was 9.3 feet in a well near Widtsoe.

In the central Sevier Valley, water levels rose between Gunnison and Redmond, southwest of Salina, east of Richfield, and between Joseph and Elsinore from March 1988 to March 1989 (fig. 25). Water levels declined southwest of Axtell, northeast and southwest of Rockyford Reservoir, between Richfield and Elsinore, and southwest of Jospeh (fig. 25). Water levels rose in 20 wells, declined in 23 wells, and remained the same in one well. The largest observed water-level rise was 1.2 feet in a well west of Monroe. The largest observed water-level decline as 3.7 feet in a well southeast of Axtell. Because withdrawals from wells in the entire area have been relatively constant over the past six years (fig. 27) and discharge of the Sevier River has been relatively constant over the past three years (fig. 27), changes in ground-water levels likely are related to local changes in well withdrawals or irrigation.

Water-level contours depicting the altitude and configuration of the potentiometric surface in the central Sevier Valley are shown in figure 26. The potentiometric surface defines the level at which water stands in tightly cased wells that penetrate the ground-water aquifer (in a flowing well, this level is above land surface). Ground water generally moves in a direction perpendicular to water-level contours and toward lower elevations. In the central Sevier Valley, ground water generally moves from south to north. Where potentiometric contours are convex in a downstream direction along a river, they indicate flow of water from the river to the aquifer (such as the area where the contours are slightly convex downstream just north of Sevier); where contours are concave downstream (such as north of Sigurd) they indicate seepage of ground water into the river.

The relation of water levels in selected wells to discharge of the Sevier River at Hatch, to cumulative departure from average annual precipitation at Panguitch, Salina, and Loa, and to annual withdrawal from wells is shown in figure 27. Precipitation in 1988 was greater-than-average at Loa and less-than-average at Panguitch and Salina. The discharge of the Sevier River at Hatch in 1988 was about 83,800 acre-feet, 3,300 acre-feet higher than the 1940-88 average annual discharge.

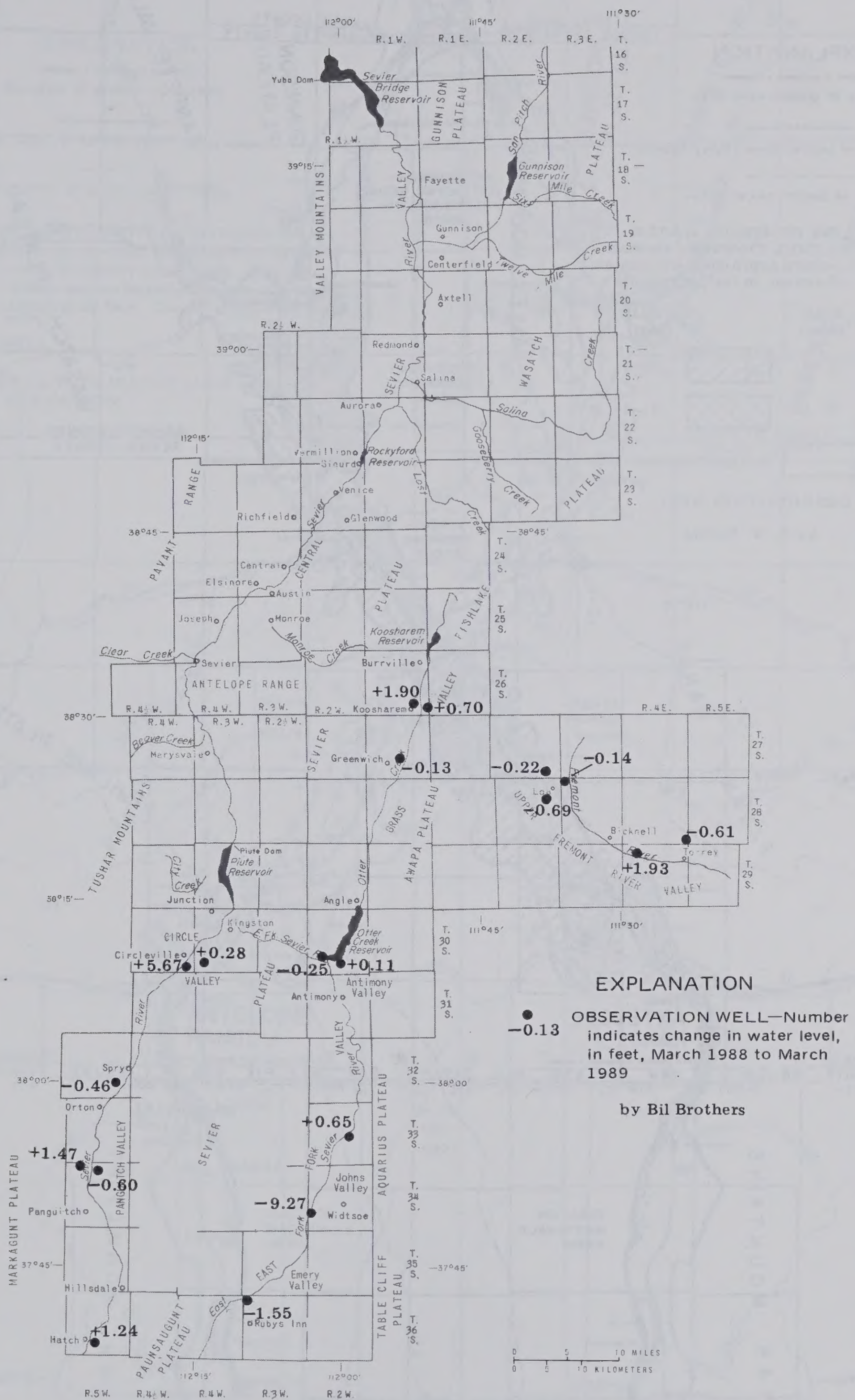


Figure 24.--Map of the upper Sevier Valley and the upper Fremont River valley showing change of water levels in selected wells from March 1988 to March 1989.

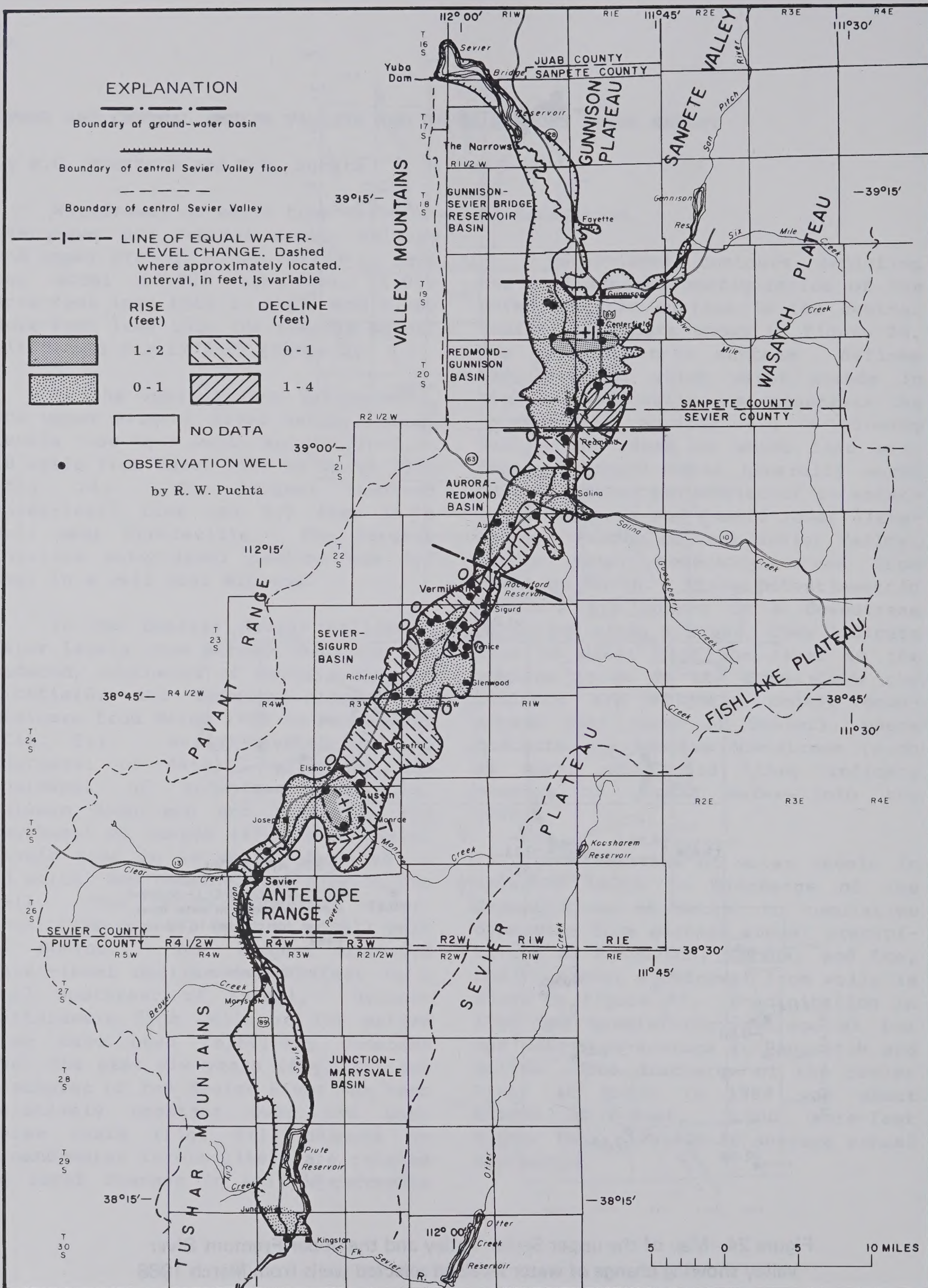


Figure 25.--Map of the central Sevier Valley showing change of water levels from March 1988 to March 1989.

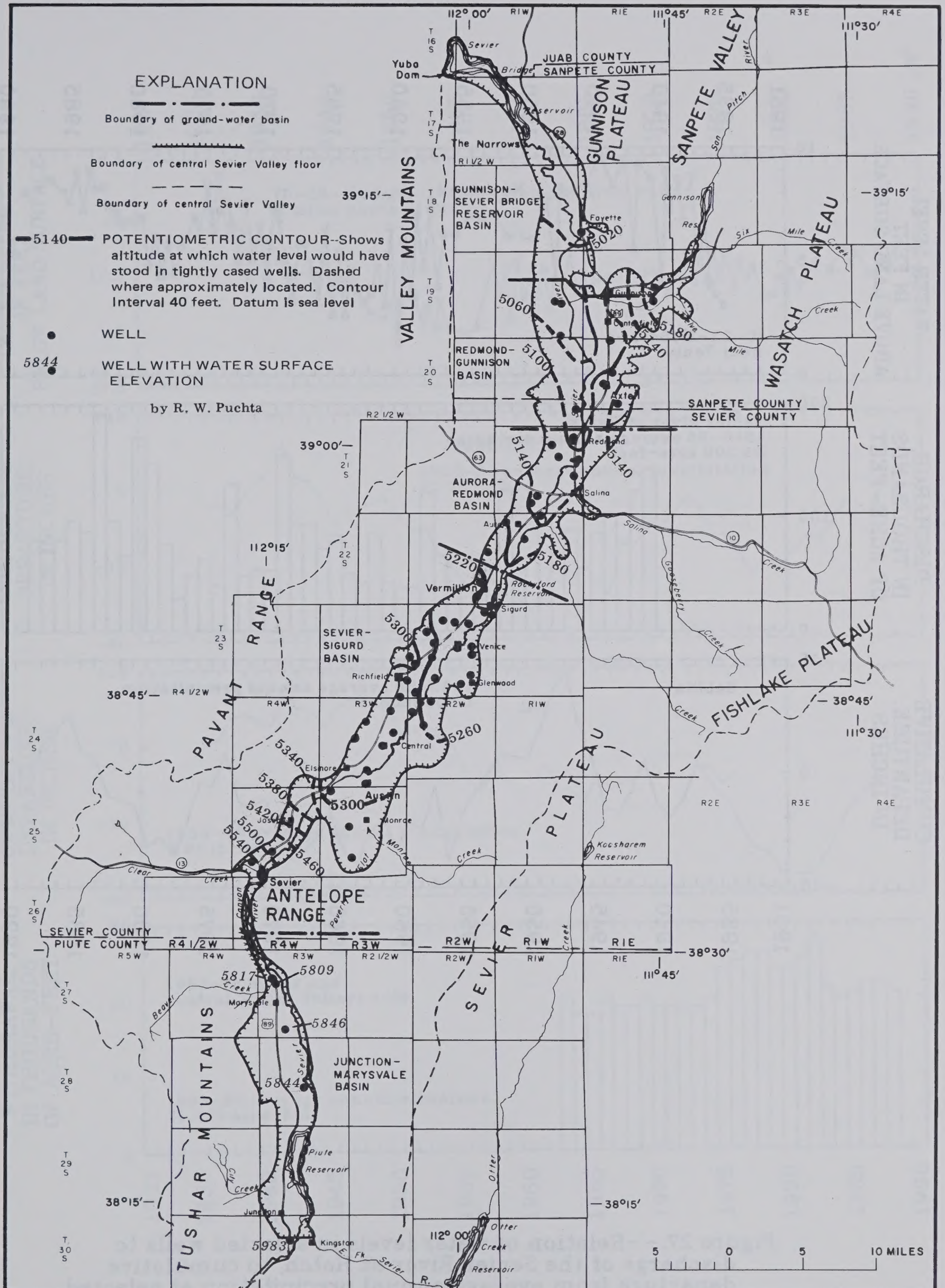


Figure 26.--Map of the central Sevier Valley showing the approximate potentiometric surface, March 1989.

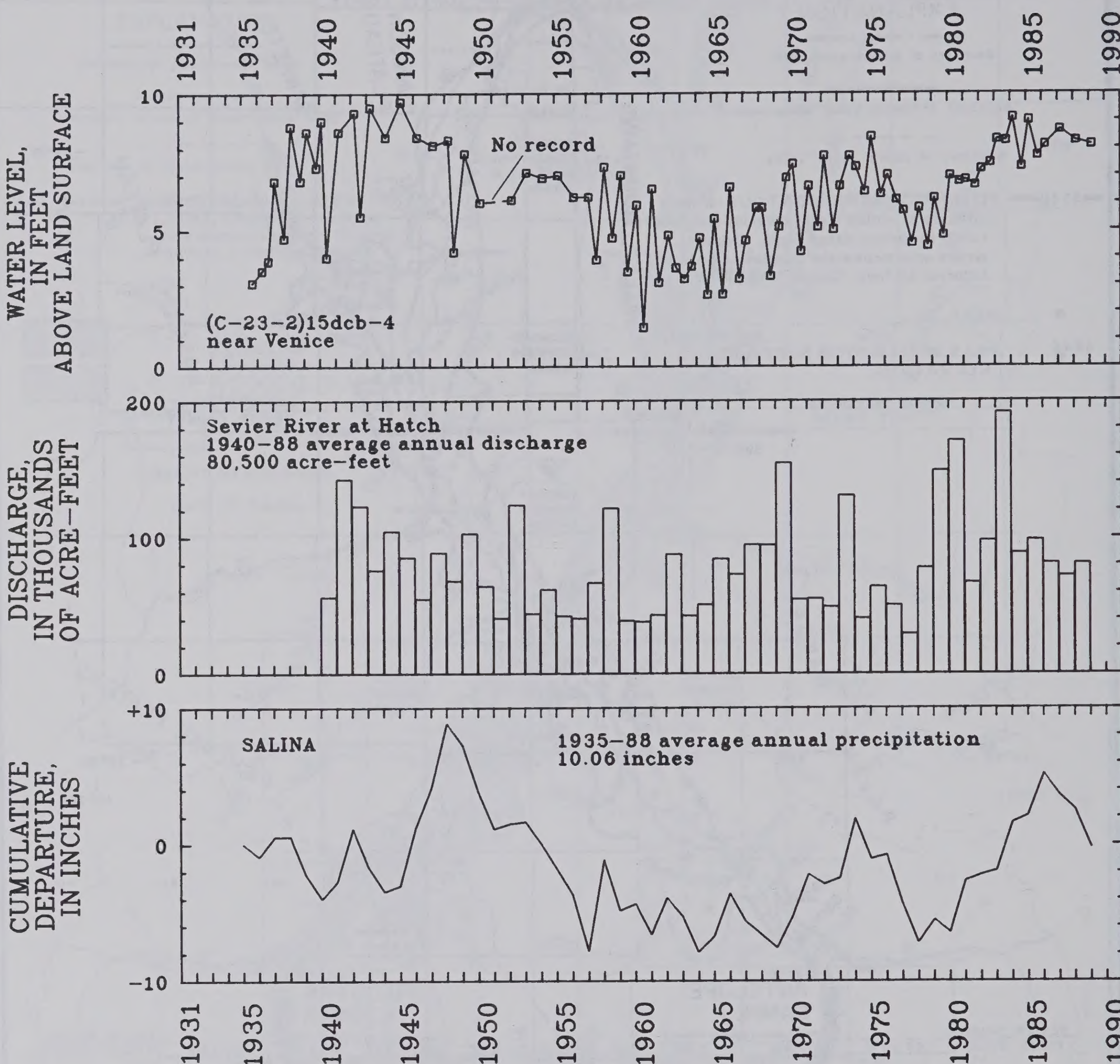


Figure 27.--Relation of water levels in selected wells to discharge of the Sevier River at Hatch, to cumulative departure from average annual precipitation at selected climate stations, and to annual withdrawal from wells--upper and central Sevier Valleys and upper Fremont River valley.

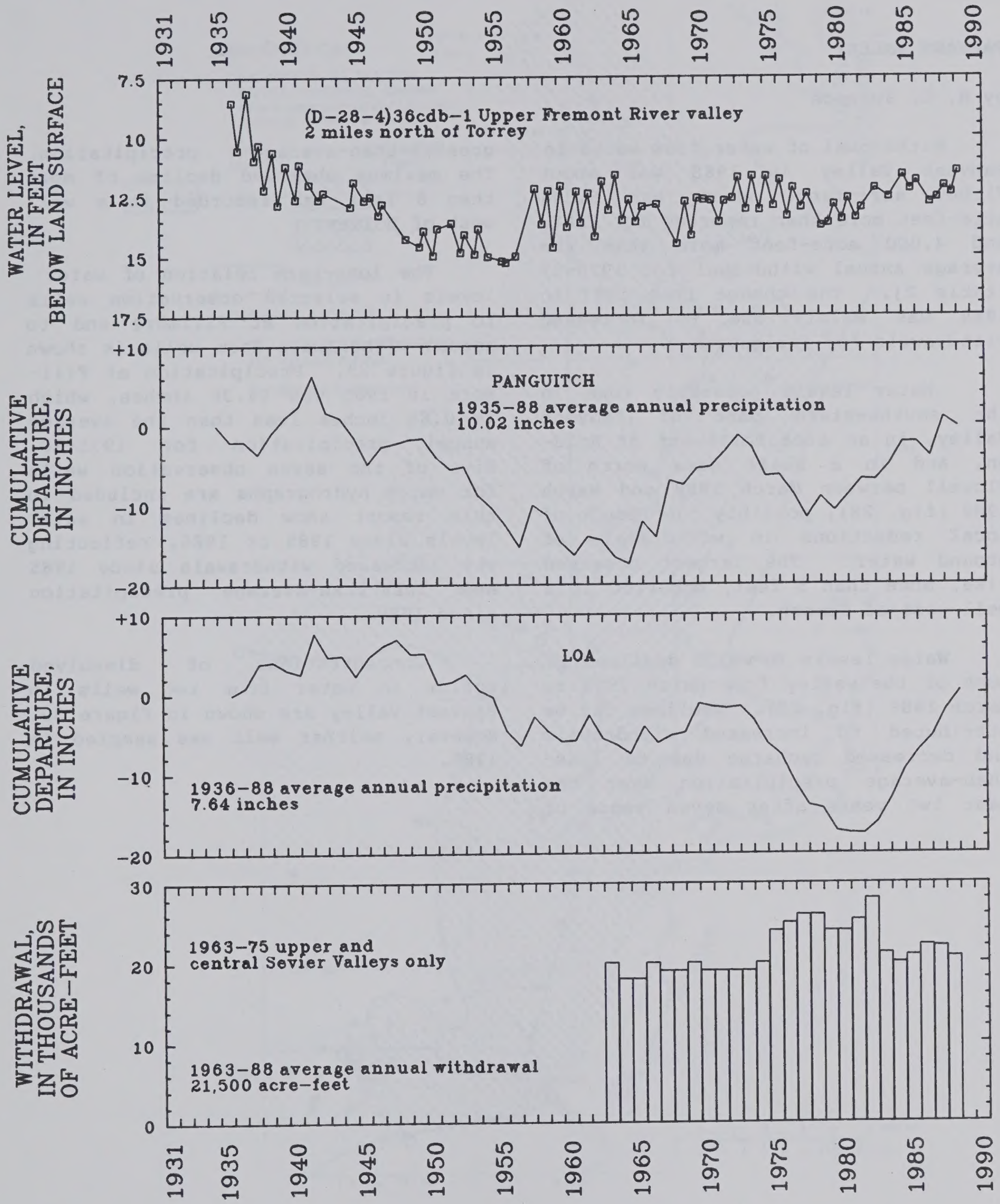


Figure 27.—Continued

PAHVANT VALLEY

by R. L. Swenson

Withdrawal of water from wells in Pahvant Valley in 1988 was about 71,000 acre-feet, which was 5,000 acre-feet more than reported for 1987, and 4,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). The change from 1987 to 1988 was mainly due to increased withdrawals for irrigation.

Water levels generally rose in the southwestern part of Pahvant Valley, in an area northwest of Holden, and in a small area north of Flowell between March 1988 and March 1989 (fig. 28), possibly the result of local reductions in withdrawals of ground water. The largest observed rise, more than 5 feet, occurred in a well west of Kanosh.

Water levels in wells declined in much of the valley from March 1988 to March 1989 (fig. 28). Declines can be attributed to increased withdrawals and decreased recharge due to less-than-average precipitation over the past two years after seven years of greater-than-average precipitation. The maximum observed decline of more than 8 feet was recorded in a well west of Holden.

The long-term relation of water levels in selected observation wells to precipitation at Fillmore and to annual withdrawals from wells is shown in figure 29. Precipitation at Fillmore in 1988 was 14.38 inches, which is 0.65 inches less than the average annual precipitation for 1931-88. Five of the seven observation wells for which hydrographs are included in this report show declines in water levels since 1985 or 1986, reflecting the increased withdrawals since 1985 and less-than-average precipitation since 1986.

Concentrations of dissolved solids in water from two wells in Pahvant Valley are shown in figure 30. However, neither well was sampled in 1988.

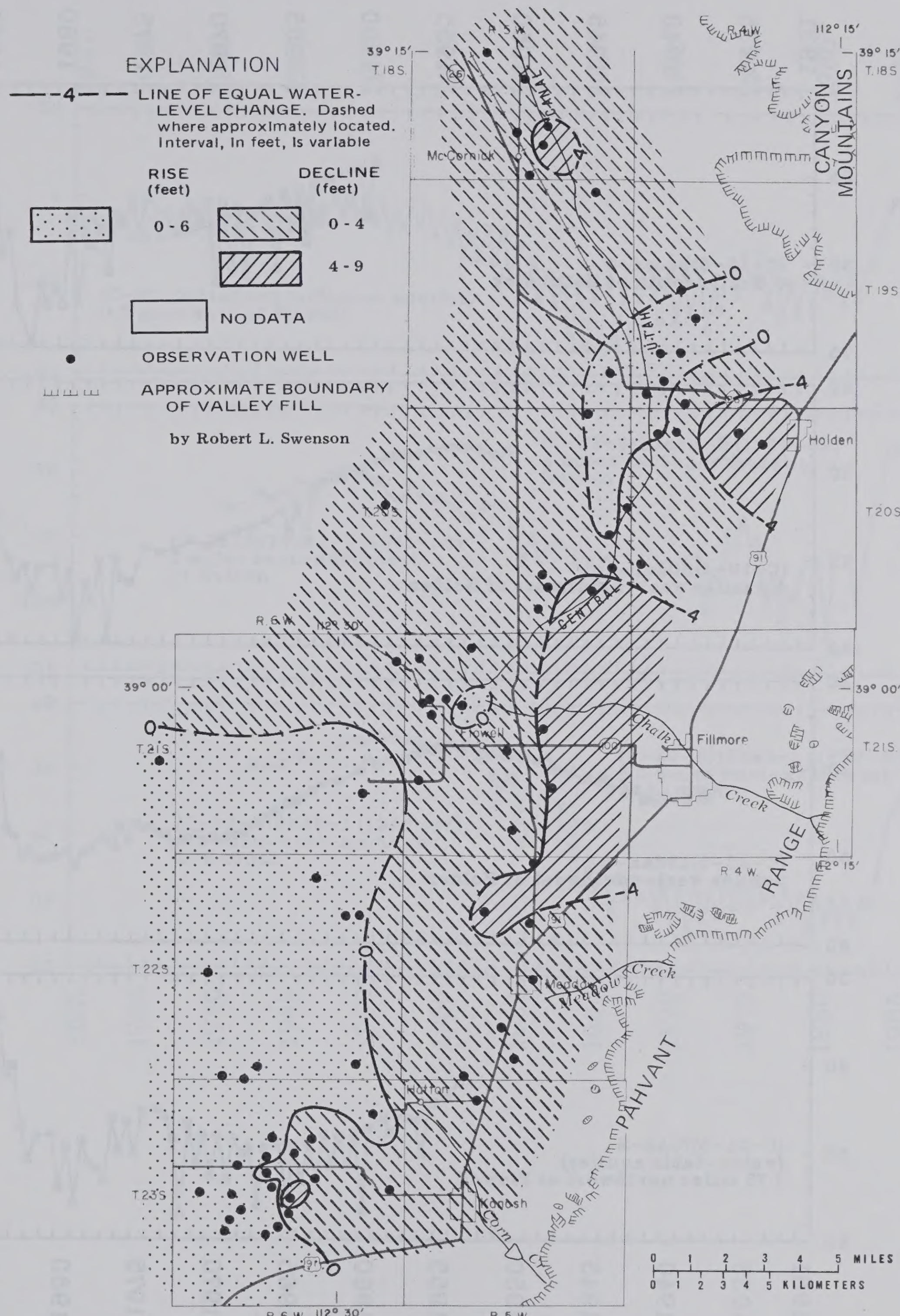


Figure 28.--Map of Pahvant Valley showing change of water levels from March 1988 to March 1989.

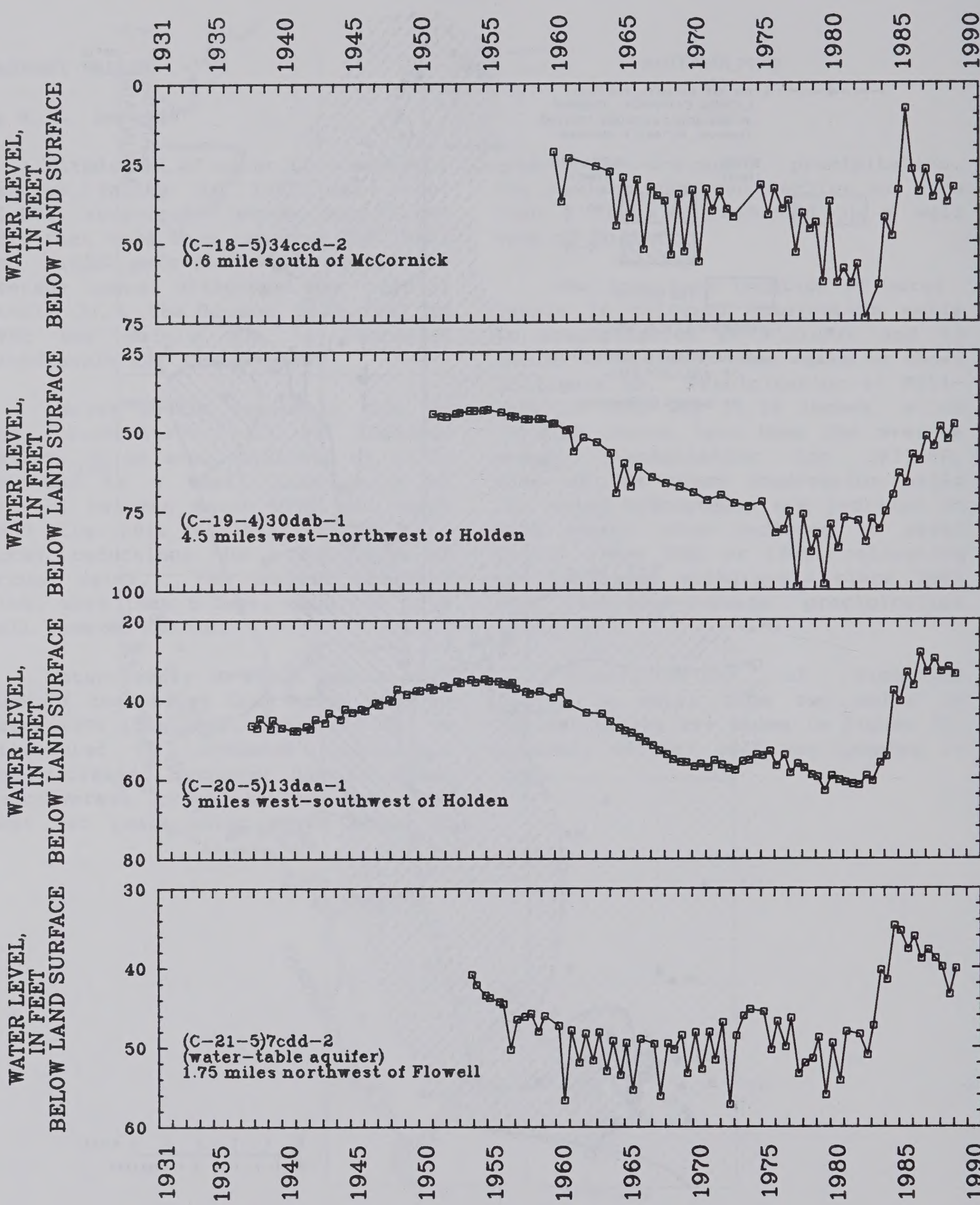


Figure 29.—Relation of water levels in selected wells in Pahvant Valley to cumulative departure from average annual precipitation at Fillmore and to annual withdrawals from wells.

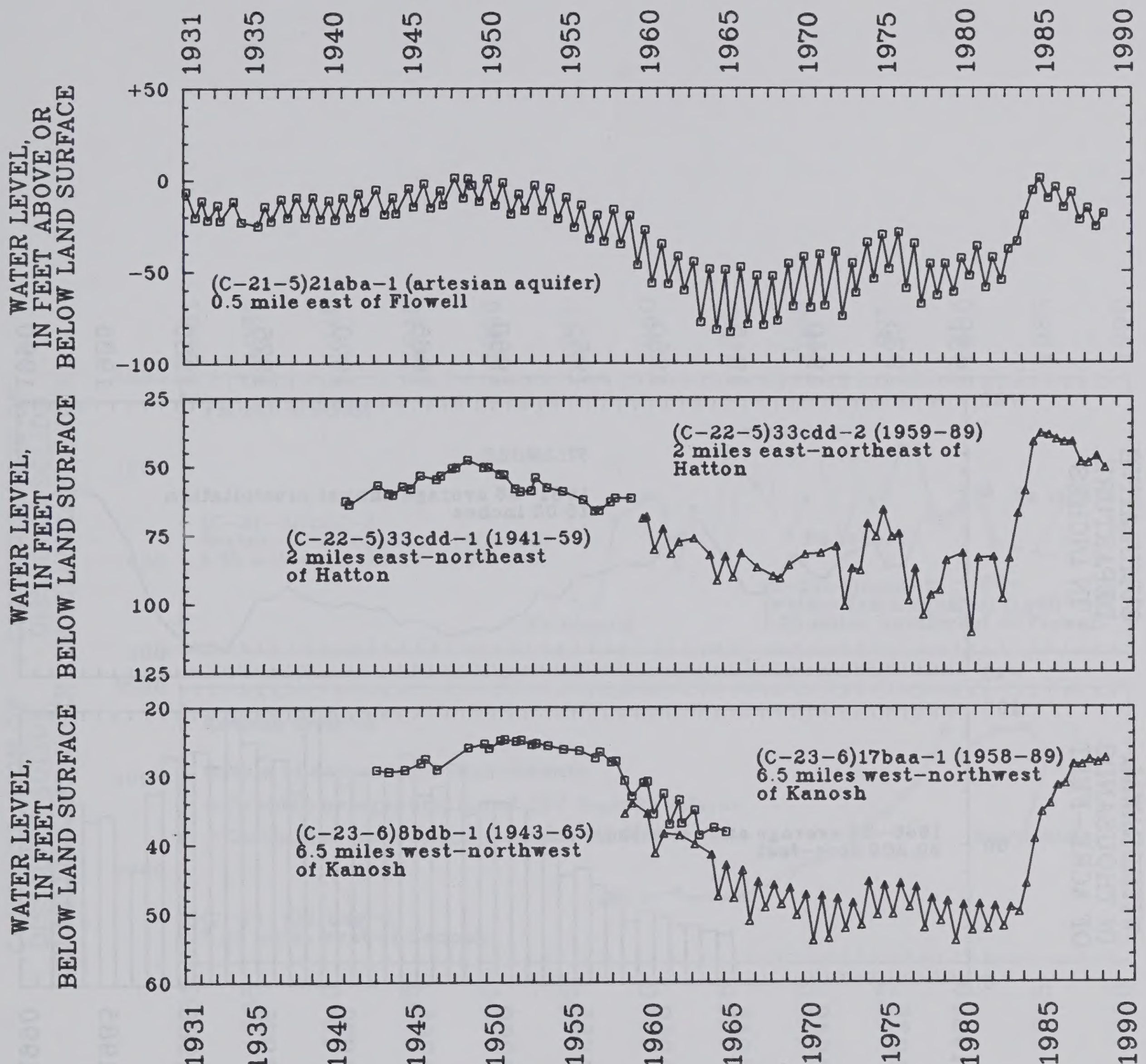


Figure 29.--Continued

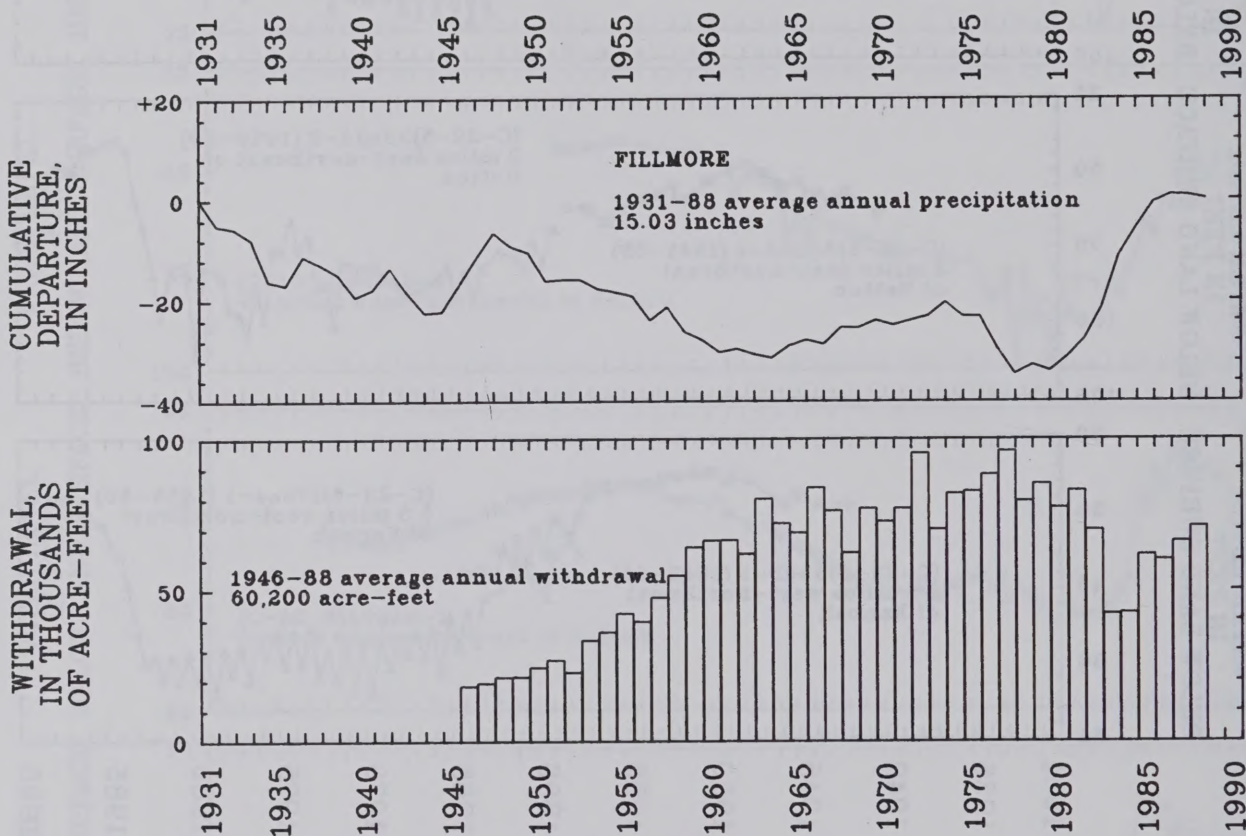


Figure 29.--Continued

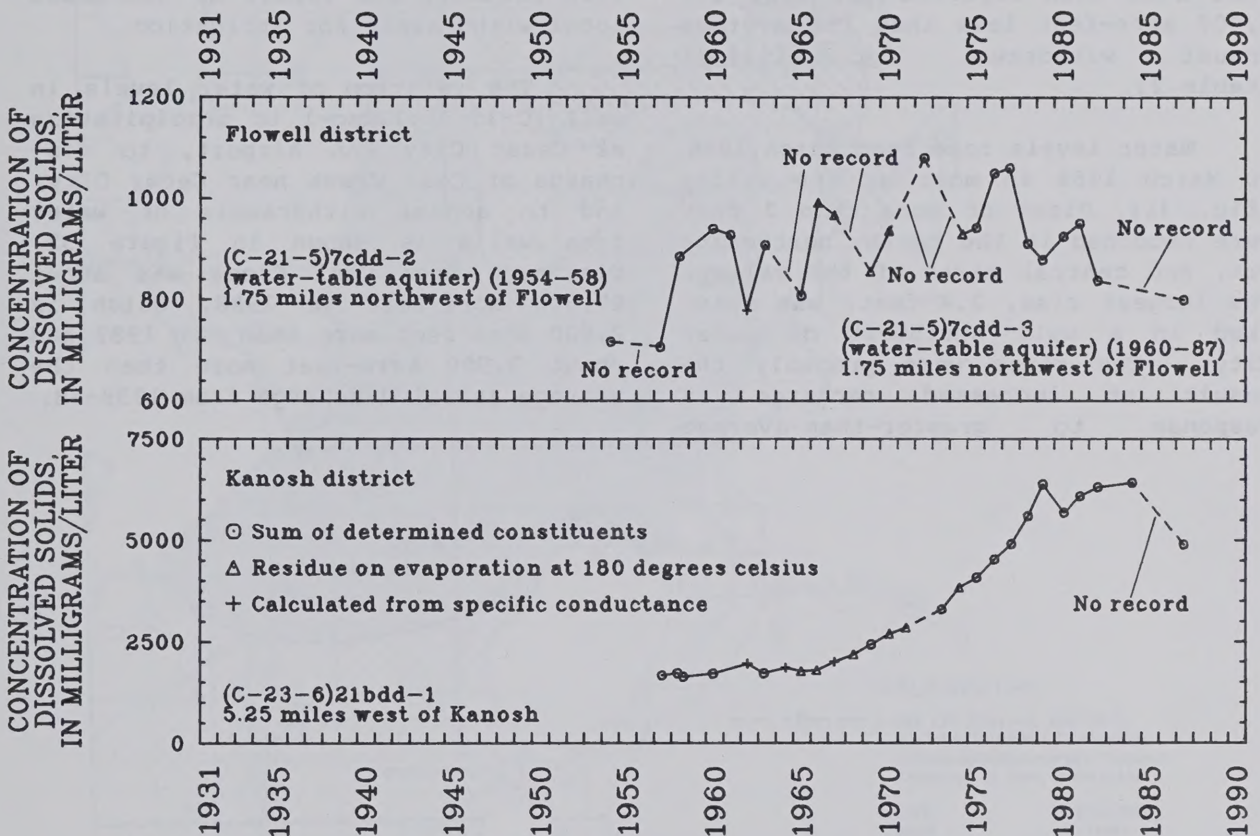


Figure 30.--Concentrations of dissolved solids in water from selected wells in Pahvant Valley.

CEDAR VALLEY, IRON COUNTY

by D.C. Emett

Withdrawal of water from wells in Cedar Valley, Iron County (formerly referred to in this series of reports as Cedar City Valley), during 1988 was about 20,000 acre-feet, 1,000 acre-feet less than reported for 1987 and 5,000 acre-feet less than the average annual withdrawal for 1978-87 (table 2).

Water levels rose from March 1988 to March 1989 in most of the valley (fig. 31). Rises of more than 2 feet were recorded in the north, northeastern, and central parts of the valley. The largest rise, 2.4 feet, was measured in a well northwest of Cedar City. The rises were probably the result of increased recharge in response to greater-than-average precipitation and a continuation of the smaller withdrawals of ground water that have occurred since 1982 (fig. 32). Declines of more than 2 feet occurred northwest of Enoch and were probably the result of increased local withdrawals for irrigation.

The relation of water levels in well (C-35-11)33aac-1 to precipitation at Cedar City FAA Airport, to discharge of Coal Creek near Cedar City, and to annual withdrawals of water from wells is shown in figure 32. Discharge from Coal Creek was about 27,300 acre-feet in 1988, which is 2,600 acre-feet more than in 1987 and about 2,900 acre-feet more than the average annual discharge from 1939-88.

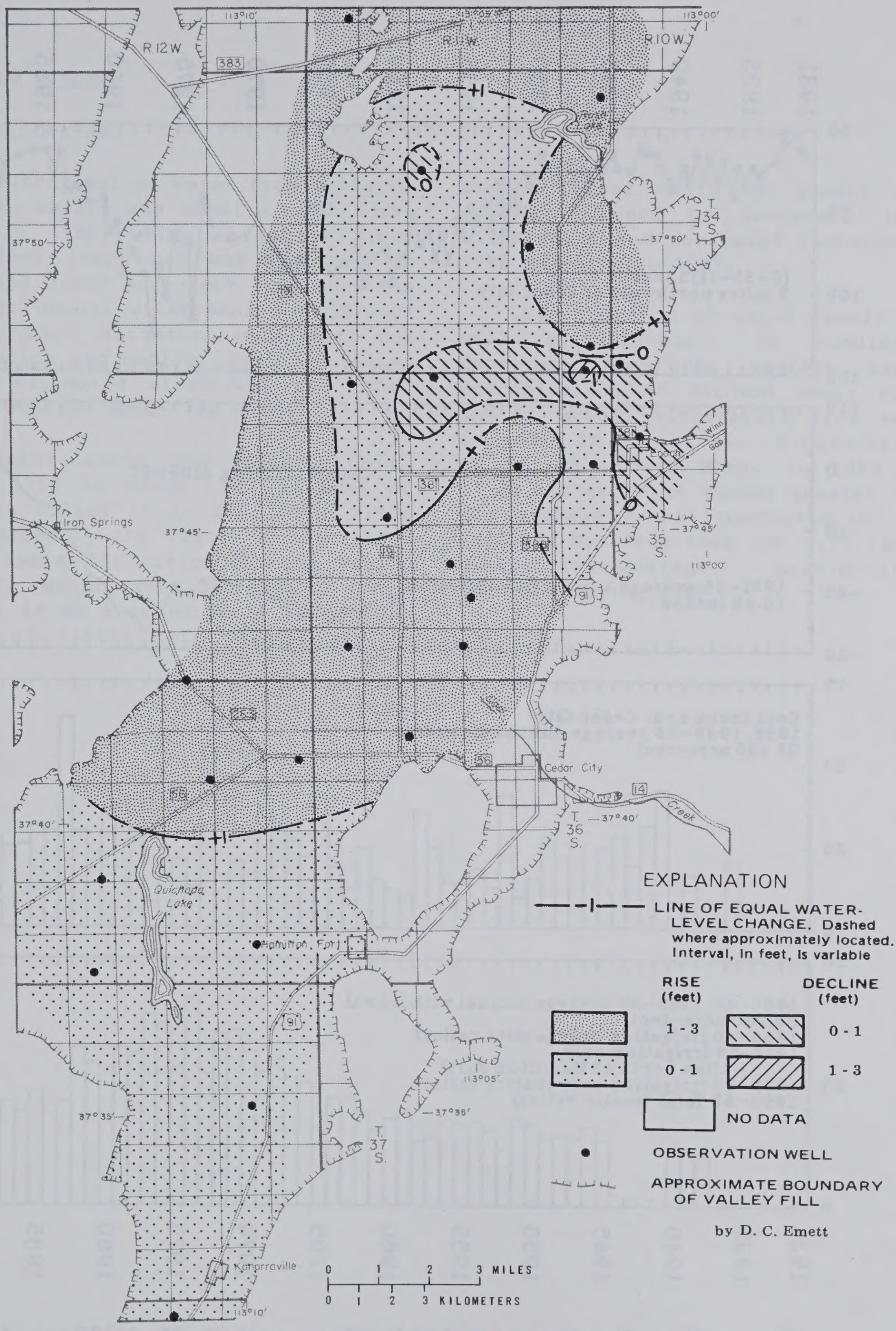


Figure 31.--Map of Cedar Valley, Iron County, showing change of water levels from March 1988 to March 1989.

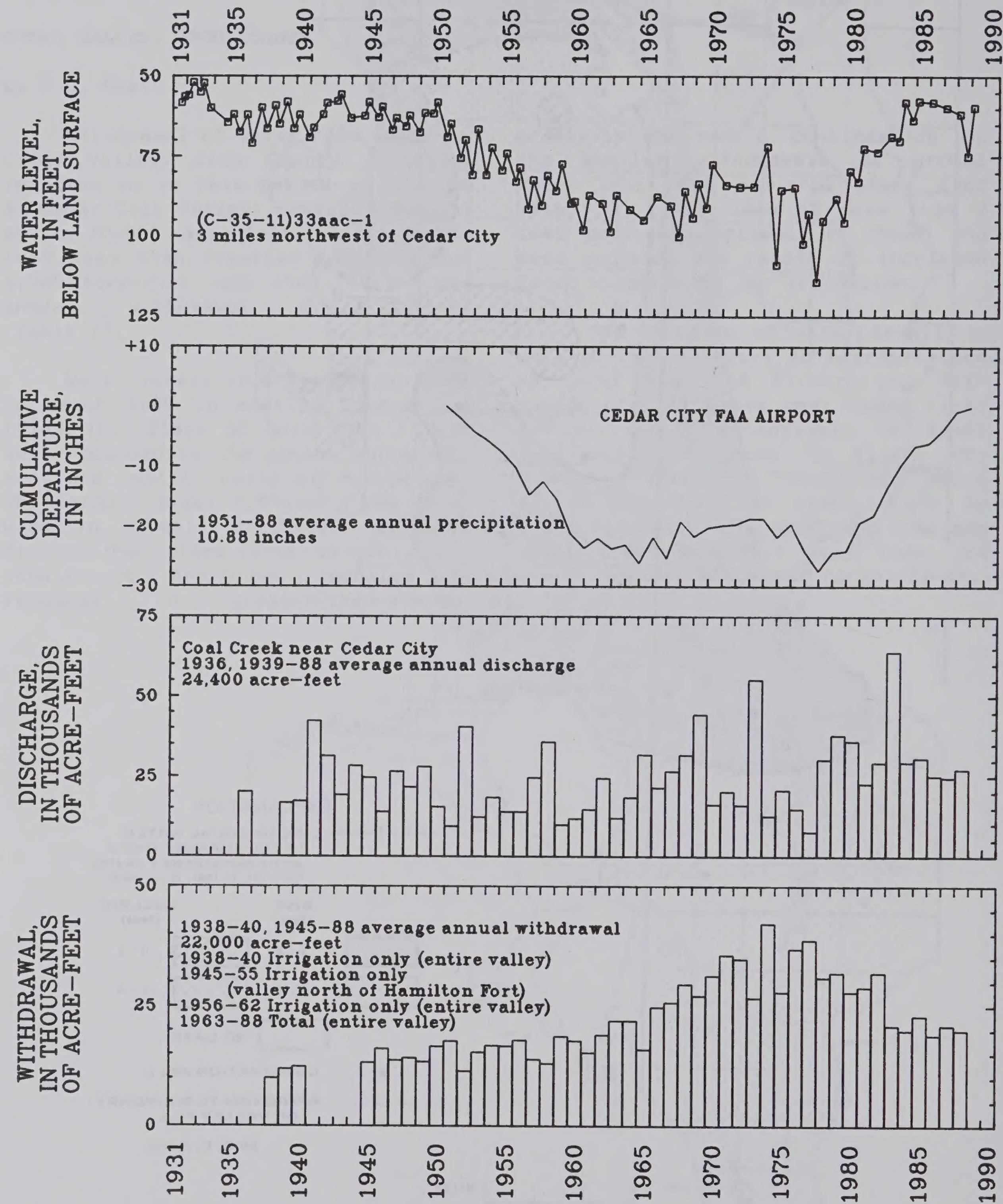


Figure 32.--Relation of water levels in well (C-35-11)33aac-1 in Cedar Valley, Iron County, to cumulative departure from the average annual precipitation at the Cedar City FAA Airport, to discharge of Coal Creek near Cedar City, and to annual withdrawals from wells.

PAROWAN VALLEY

by W.R. Overman

Withdrawal of water from wells in Parowan Valley was about 20,000 acre-feet in 1988, which was about 2,000 acre-feet less than was reported in 1987 and 5,000 acre-feet less than the average annual withdrawal for 1978-87 (table 2). Estimated withdrawal for irrigation and public supply decreased while estimated withdrawal for other uses remained about the same.

Water levels rose slightly from March 1988 to March 1989 in most of Parowan Valley (fig. 33). The rises were probably the result of decreased withdrawals for irrigation and public supply. Water-level declines of up to 3 feet in an area north of Paragonah, south of little Salt Lake, and in smaller areas north of Summit were probably caused by increased local withdrawals and decreased recharge in 1988 compared to 1987.

The relation of water levels in well (C-34-8)5bca-1 to cumulative departure from the average annual precipitation at Parowan Power Plant and to annual withdrawals from wells is shown in figure 34. Precipitation at Parowan Power Plant in 1988 was 12.62 inches, 0.19 inches greater than the average annual precipitation for 1935-88, but less than the 2.77 inches greater-than-average precipitation recorded during 1987.

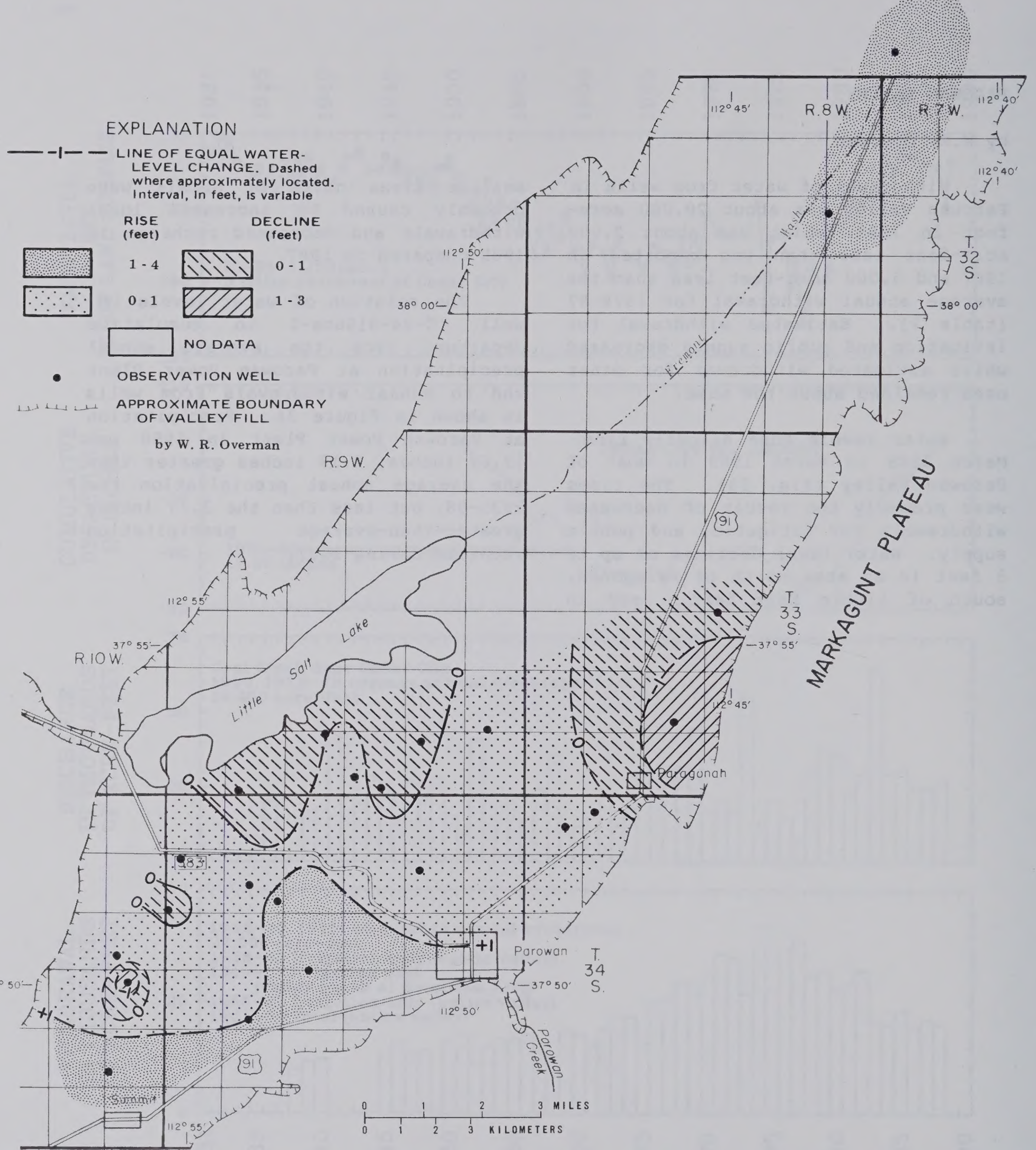


Figure 33.--Map of Parowan Valley showing change of water levels from March 1988 to March 1989.

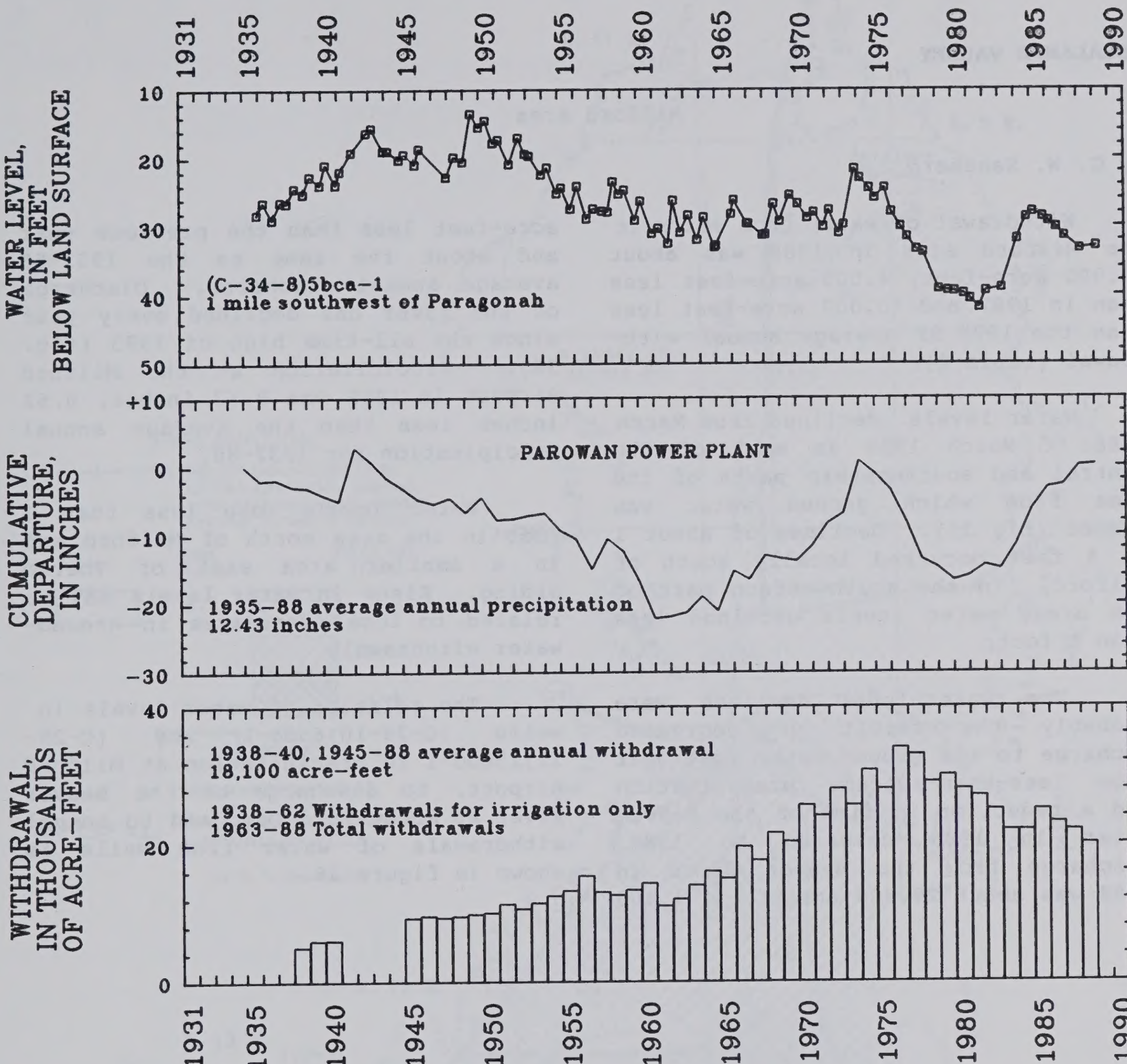


Figure 34.--Relation of water levels in well (C-34-8)5bca-1 in Parowan Valley to cumulative departure from the average annual precipitation at Parowan Power Plant and to annual withdrawals from wells.

ESCALANTE VALLEY

Milford area

by G. W. Sandberg

Withdrawal of water from wells in the Milford area in 1988 was about 40,000 acre-feet, 4,000 acre-feet less than in 1987 and 10,000 acre-feet less than the 1978-87 average annual withdrawal (table 2).

Water levels declined from March 1988 to March 1989 in most of the central and southwestern parts of the area from which ground water was pumped (fig 35). Declines of about 1 to 4 feet occurred locally south of Milford. In the southwestern part of the area, water levels declined less than 1 foot.

The water-level declines were probably the result of decreased recharge to the ground-water reservoir from less-than-average precipitation and a reduction in flow of the Beaver River in 1988 compared to 1987. Discharge from the Beaver River in 1988 was about 29,900 acre-feet, 1,100 acre-feet less than the previous year and about the same as the 1931-88 average annual discharge. Discharge of the river has declined every year since the all-time high of 1983 (fig. 36). Precipitation at the Milford Airport in 1988 was 8.43 inches, 0.52 inches less than the average annual precipitation for 1932-88.

Water levels rose less than 1 foot in the area north of Milford and in a smaller area east of Thermo Siding. Rises in water levels may be related to local decreases in ground-water withdrawals.

The relation of water levels in wells (C-29-10)6ddc-1 and (C-29-11)13add-1 to precipitation at Milford Airport, to discharge of the Beaver River at Rocky Ford Dam, and to annual withdrawals of water from wells is shown in figure 36.

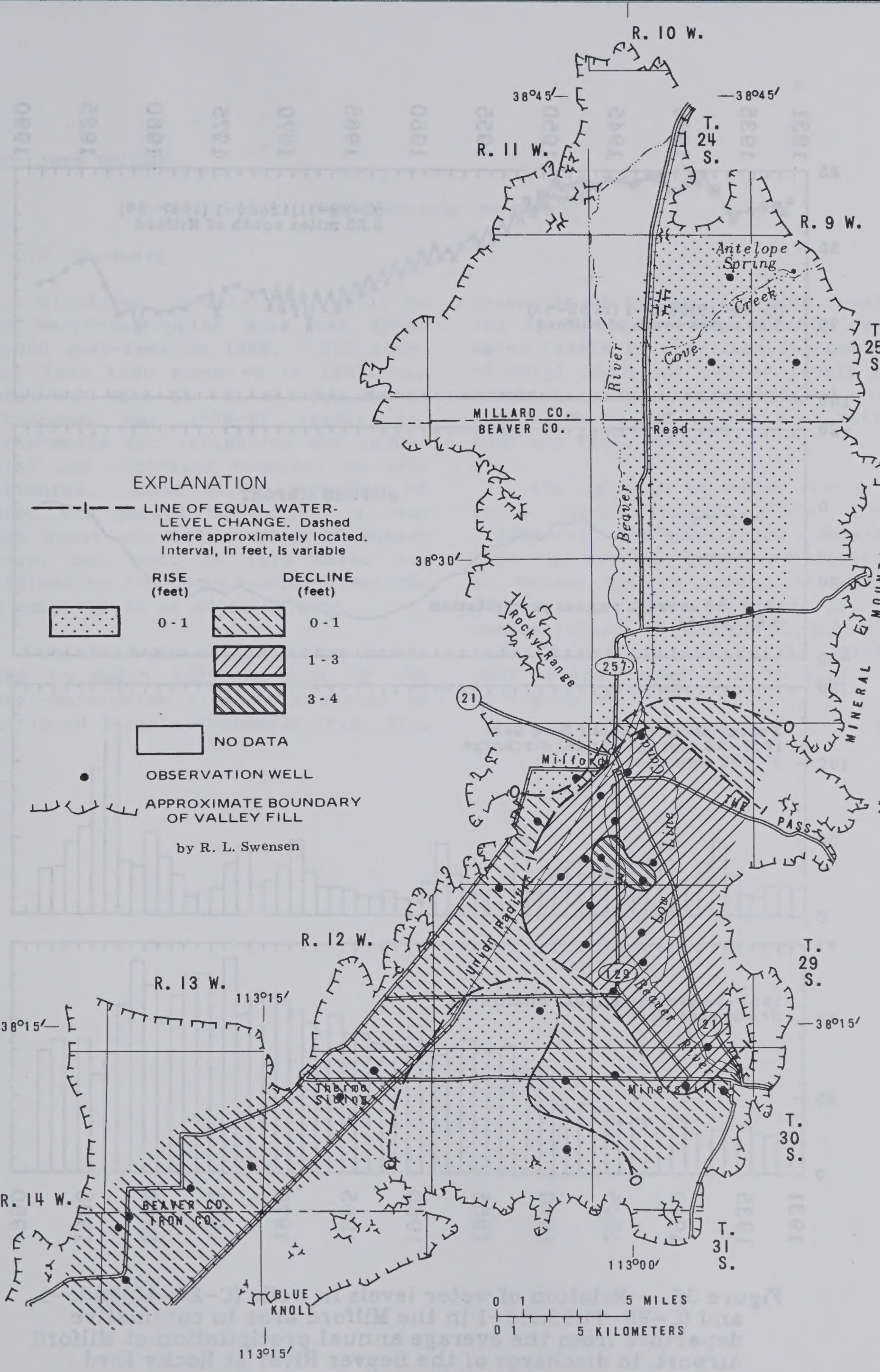


Figure 35.--Map of the Milford area showing change of water levels from March 1988 to March 1989.

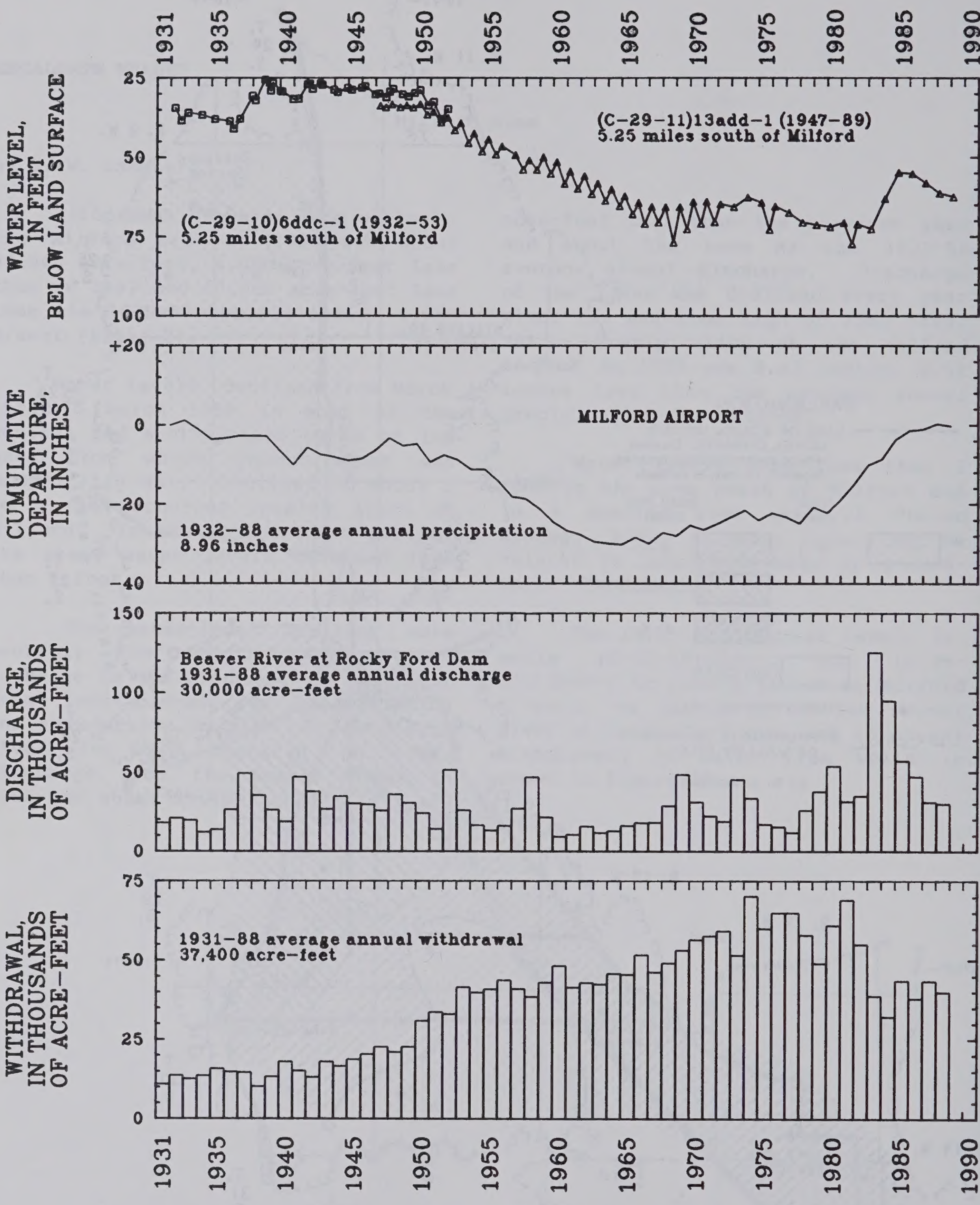


Figure 36.--Relation of water levels in wells (C-29-10)6ddc-1 and (C-29-11)13add-1 in the Milford area to cumulative departure from the average annual precipitation at Milford Airport, to discharge of the Beaver River at Rocky Ford Dam, and to annual withdrawals from wells.

ESCALANTE VALLEY

Beryl-Enterprise area

by G.W. Sandberg

Withdrawal of water from wells in the Beryl-Enterprise area was about 88,000 acre-feet in 1988, 9,000 acre-feet less than reported in 1987, and about the same as the average annual withdrawal for 1978-87 (table 2). Withdrawals for irrigation and industrial use decreased compared to 1987 estimates. About 19,000 acre-feet of water was pumped to dewater a mine area about six miles north of Enterprise, but most of this water was returned to the ground-water reservoir as recharge in an adjacent area.

Water levels declined from March 1988 to March 1989 in most of the Beryl-Enterprise area as a result of continued large withdrawals (fig. 37). Cessation of pumping for mine dewatering in December 1988 probably caused water levels to rise locally southwest of Beryl Junction. Water levels rose slightly in areas southeast and northwest of Beryl and in the area between Lund and Table Butte.

The relation of water levels in wells (C-35-17)25cdd-1 and (C-35-17)25dcd-1 to cumulative departure from the average annual precipitation at Modena and to annual withdrawals from wells is shown in figure 38. The concentration of dissolved solids in well (C-34-16)28dcc-2 in the northern part of the pumped area is also shown in figure 38.

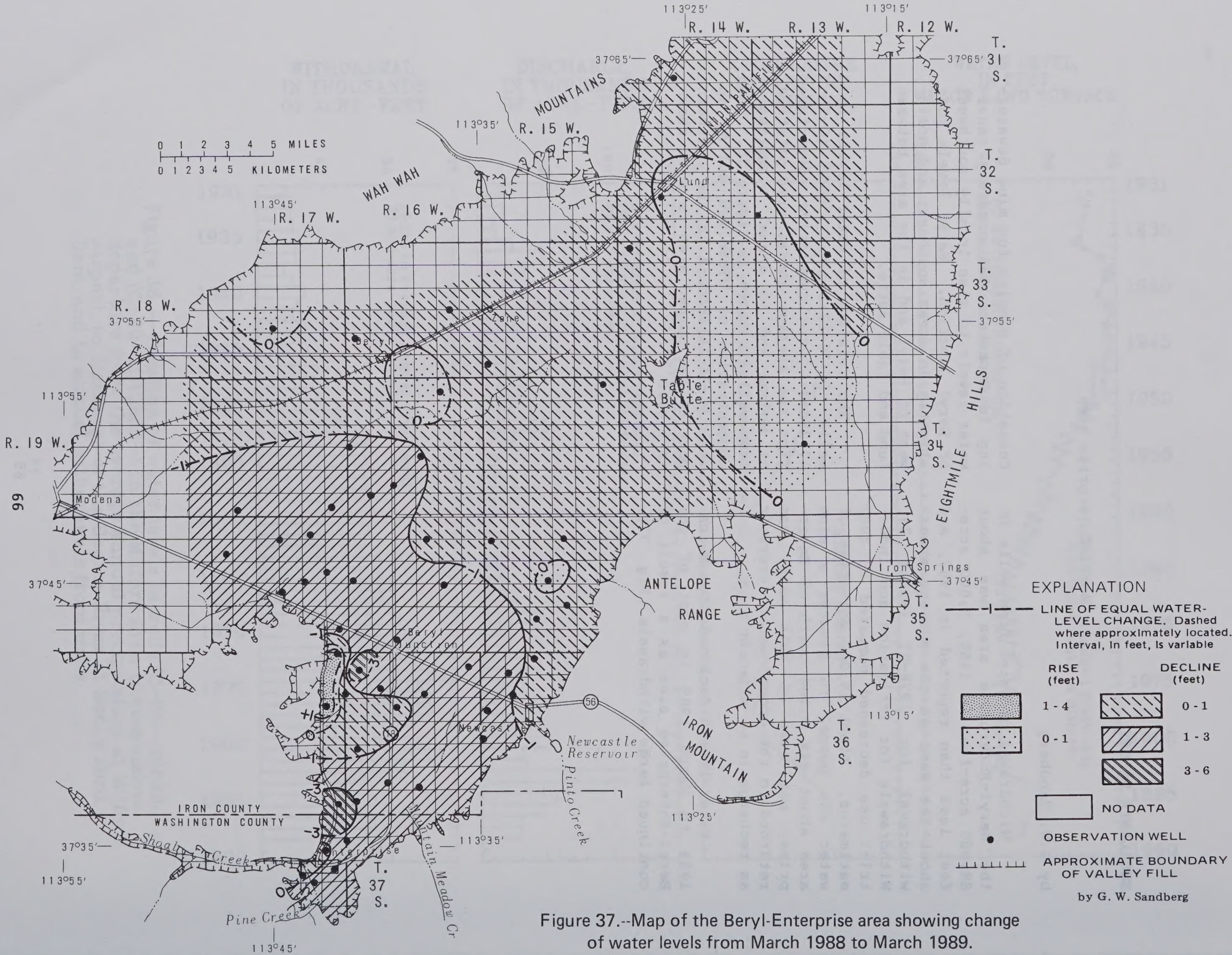


Figure 37.--Map of the Beryl-Enterprise area showing change of water levels from March 1988 to March 1989.

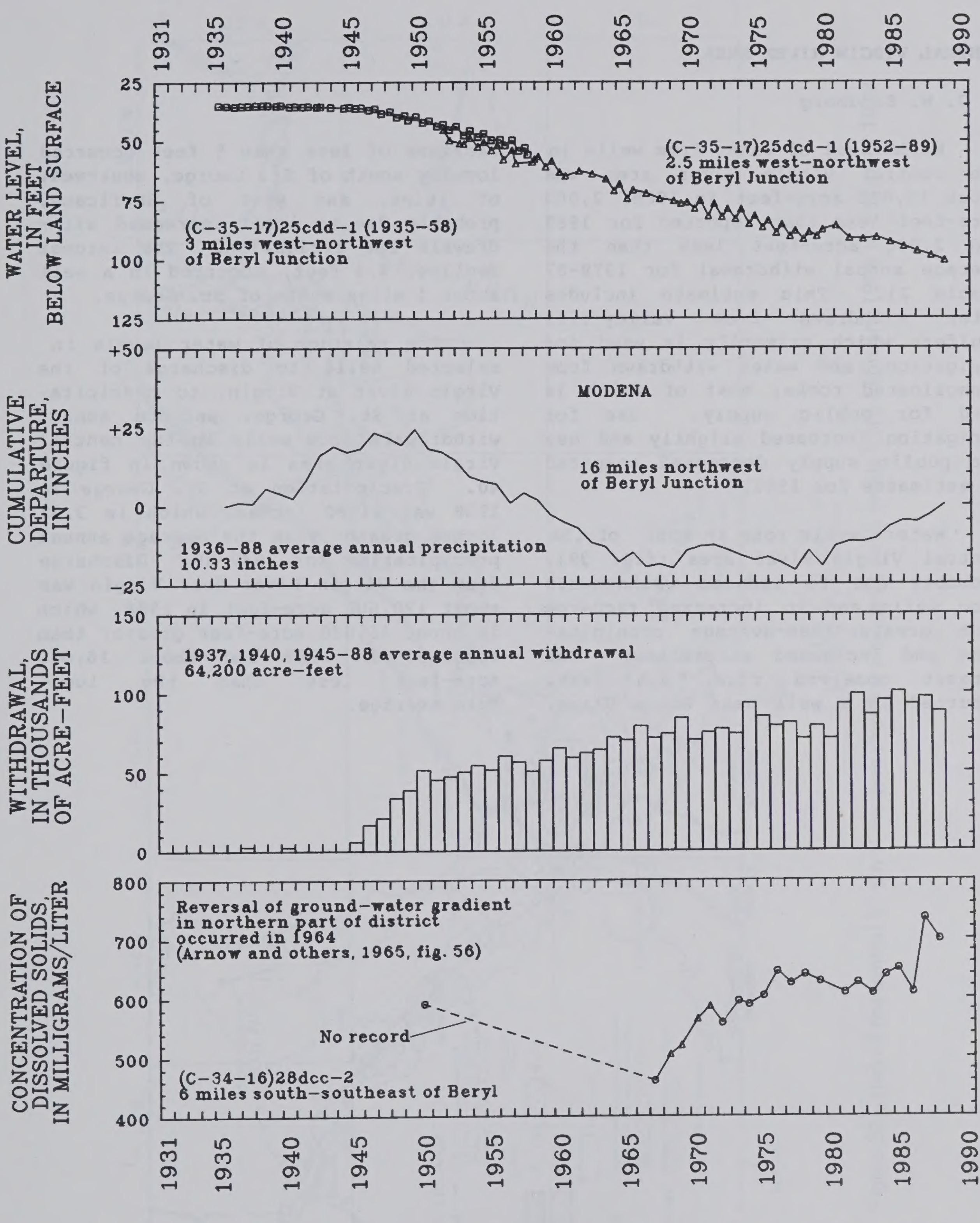


Figure 38.--Relation of water levels in wells (C-35-17)25cdd-1 and (C-35-17)25dcd-1 in the Beryl-Enterprise area to cumulative departure from the average annual precipitation at Modena, to annual withdrawals from wells, and to concentration of dissolved solids in well (C-34-16)28dcc-2.

CENTRAL VIRGIN RIVER AREA

by G. W. Sandberg

Withdrawal of water from wells in the central Virgin River area was about 18,000 acre-feet in 1988, 2,000 acre-feet less than reported for 1987 and 2,000 acre-feet less than the average annual withdrawal for 1978-87 (table 2). This estimate includes water withdrawn from valley-fill aquifers which primarily is used for irrigation, and water withdrawn from consolidated rocks, most of which is used for public supply. Use for irrigation increased slightly and use for public supply decreased compared to estimates for 1987.

Water levels rose in most of the central Virgin River area (fig. 39), probably due to reduced withdrawals from wells and to increased recharge from greater-than-average precipitation and increased streamflow. The largest observed rise, 9.5 feet, occurred in a well near Santa Clara. Declines of less than 5 feet occurred locally south of St. George, southwest of Ivins, and west of Hurricane, probably due to local increased withdrawals for irrigation. The largest decline, 4.4 feet, occurred in a well about 4 miles south of St. George.

The relation of water levels in selected wells to discharge of the Virgin River at Virgin, to precipitation at St. George, and to annual withdrawals from wells in the central Virgin River area is shown in figure 40. Precipitation at St. George in 1988 was 11.80 inches, which is 3.82 inches greater than the average annual precipitation for 1947-88. Discharge from the Virgin River near Virgin was about 120,600 acre-feet in 1988, which is about 16,000 acre-feet greater than reported in 1987 and about 16,000 acre-feet less than the long-term average.

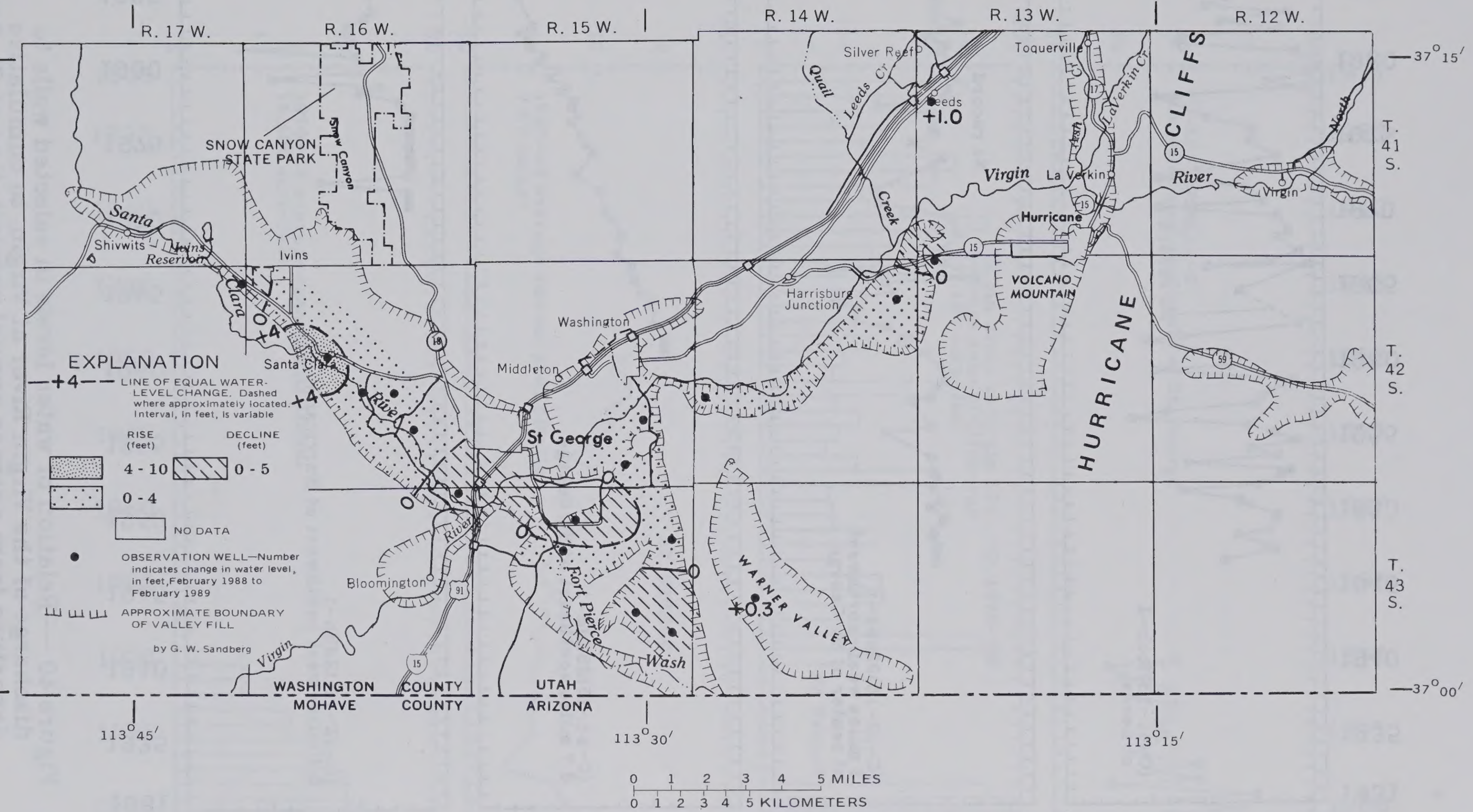


Figure 39.--Map of the central Virgin River area showing change of water levels from February 1988 to February 1989.

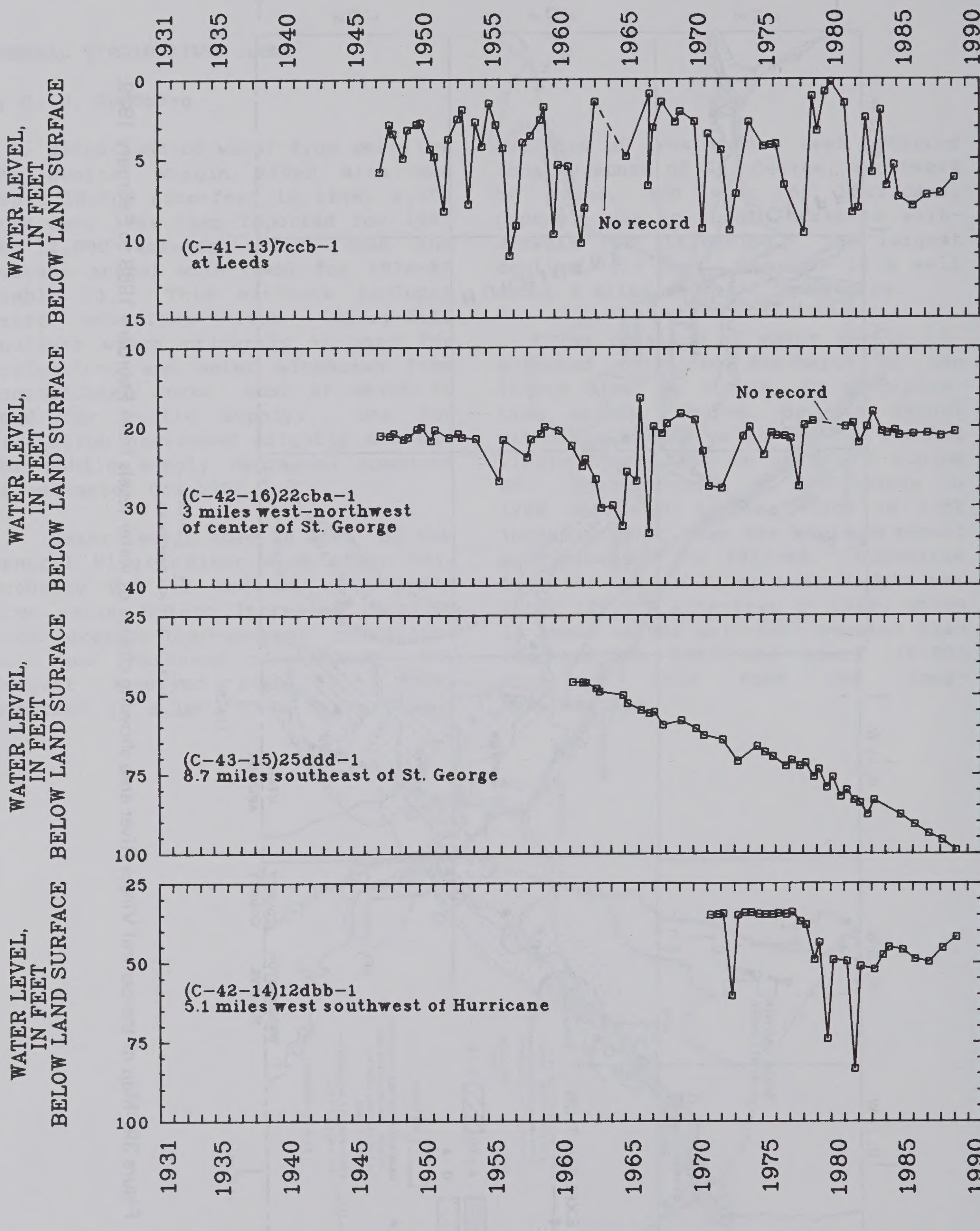


Figure 40.--Relation of water levels in selected wells to discharge of the Virgin River at Virgin, to cumulative departure from average annual precipitation at St. George, and to annual withdrawals from wells in the Central Virgin River area.

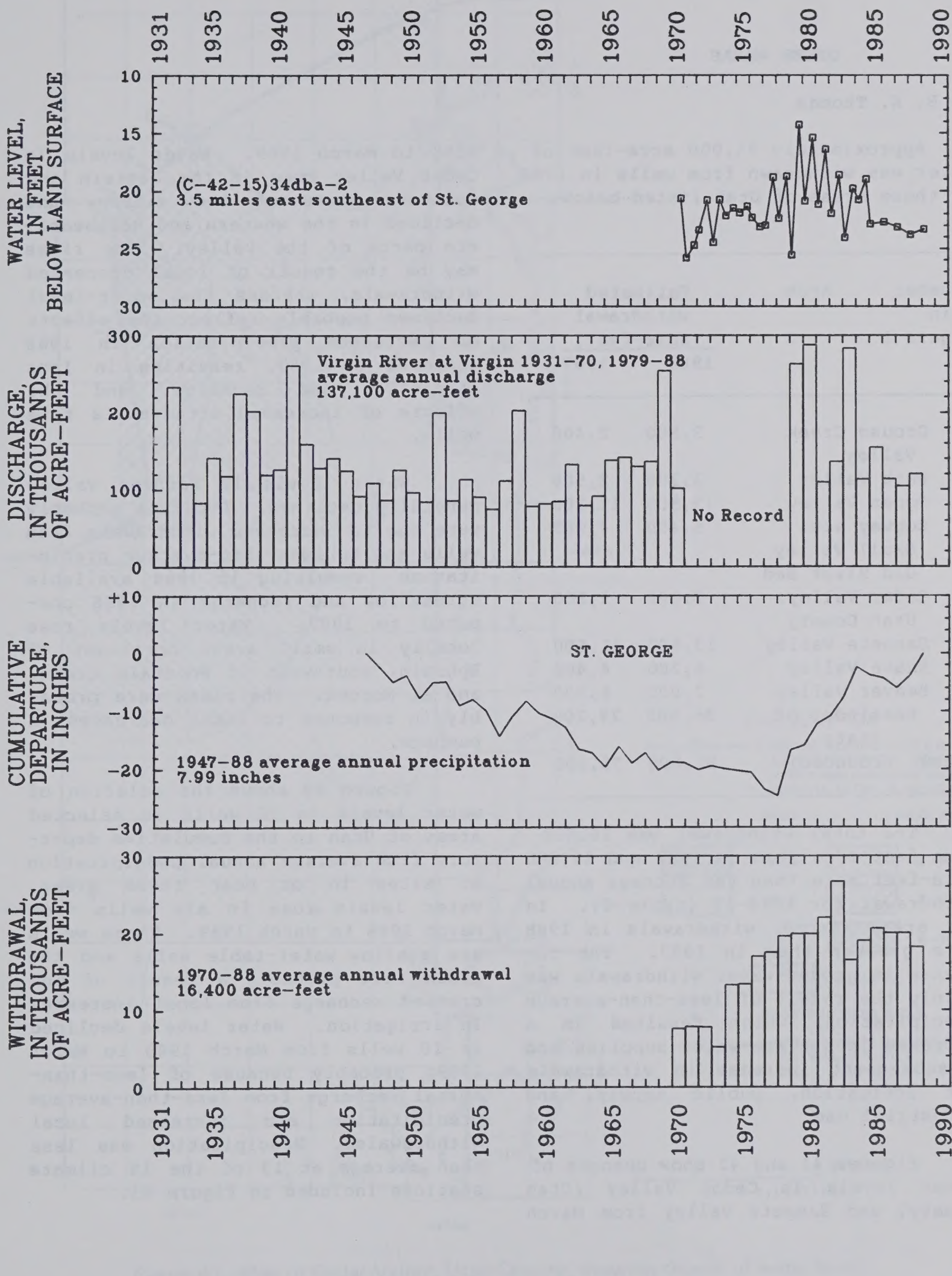


Figure 40.--Continued

OTHER AREAS

by B. K. Thomas

Approximately 91,000 acre-feet of water was withdrawn from wells in 1988 in those areas of Utah listed below:

Number in figure 1	Area	Estimated withdrawal (acre-feet) 1988	1987
1	Grouse Creek Valley	3,500	2,400
2	Park Valley	3,300	2,500
8	Ogden Valley	13,500	11,300
12	Dugway area Skull Valley Old River Bed	5,400	4,900
13	Cedar Valley, Utah County	2,000	1,800
18	Sanpete Valley	13,600	11,600
23	Snake Valley	6,200	4,400
25	Beaver Valley	7,000	6,800
	Remainder of State	36,500	29,200
Total (rounded)		91,000	75,000

The total withdrawal was 16,000 acre-feet more than in 1987 and 14,000 acre-feet more than the average annual withdrawal for 1978-87 (table 2). In all areas listed, withdrawals in 1988 were greater than in 1987. The increase in ground-water withdrawals was mainly the result of less-than-average precipitation, which resulted in a decrease in surface-water supplies and a subsequent increase in withdrawals for irrigation, public supply, and industrial use.

Figures 41 and 42 show changes of water levels in Cedar Valley (Utah County) and Sanpete Valley from March 1988 to March 1989. Water levels in Cedar Valley rose in the eastern and southern parts of the valley, and declined in the western and northeastern parts of the valley. The rises may be the result of local decreased withdrawals, whereas the water-level declines probably reflect the effects of decreased precipitation in 1988 compared to 1987, resulting in less streamflow and recharge, and the effects of increased withdrawals from wells.

Water levels in Sanpete Valley generally declined. Declines probably were due to increased withdrawals from wells and to less-than-average precipitation resulting in less available streamflow and recharge in 1988 compared to 1987. Water levels rose locally in small areas northeast of Ephraim, southwest of Fountain Green, and at Moroni. The rises were probably in response to local decreases in pumpage.

Figure 43 shows the relation of water levels in 16 wells in selected areas of Utah to the cumulative departure from average annual precipitation at sites in or near those areas. Water levels rose in six wells from March 1988 to March 1989. These wells are shallow water-table wells and the rises were probably a result of increased recharge from local increases in irrigation. Water levels declined in 10 wells from March 1988 to March 1989, probably because of less-than-normal recharge from less-than-average precipitation and increased local withdrawals. Precipitation was less than average at 13 of the 15 climate stations included in figure 43.

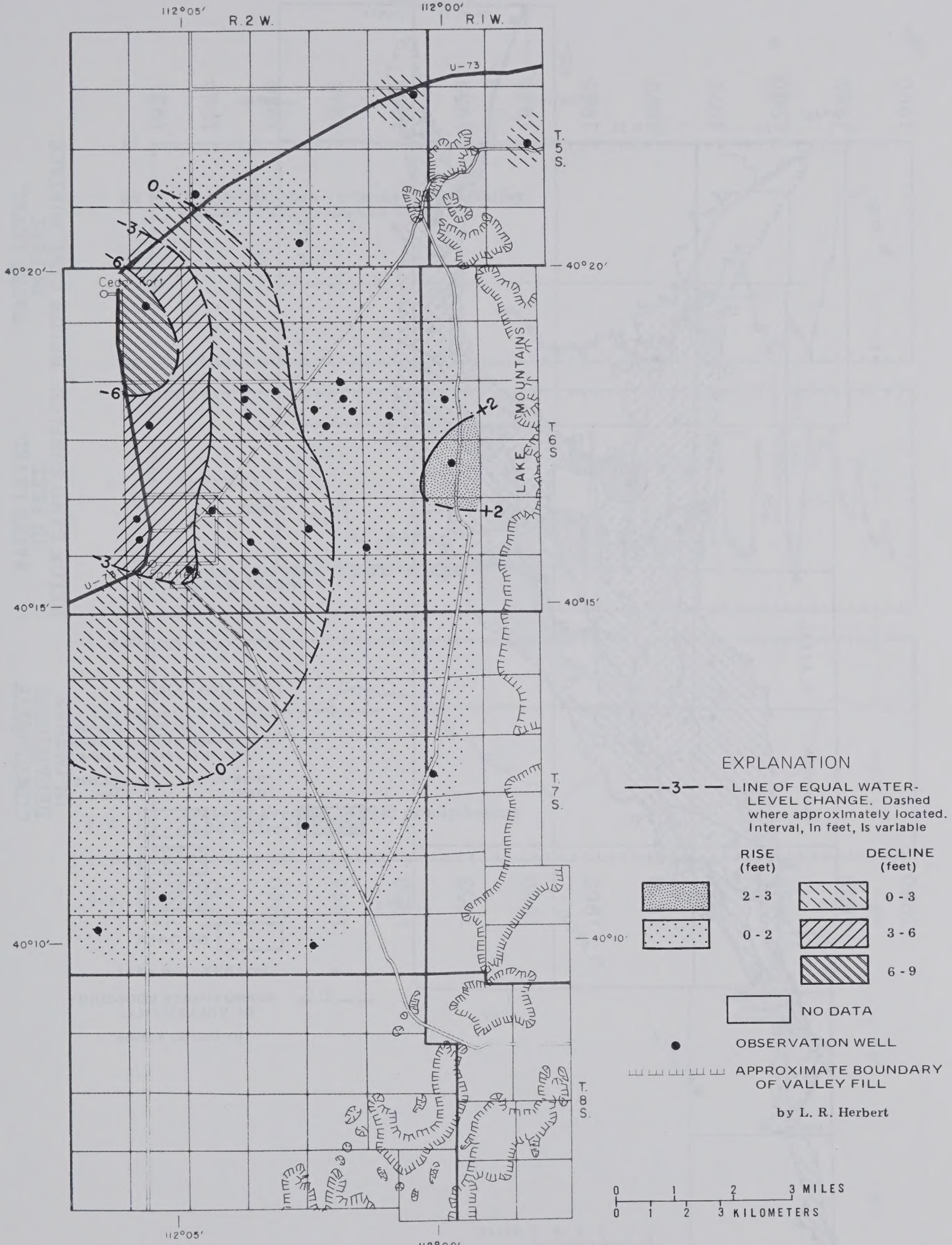


Figure 41.--Map of Cedar Valley, Utah County, showing change of water levels from March 1988 to March 1989.

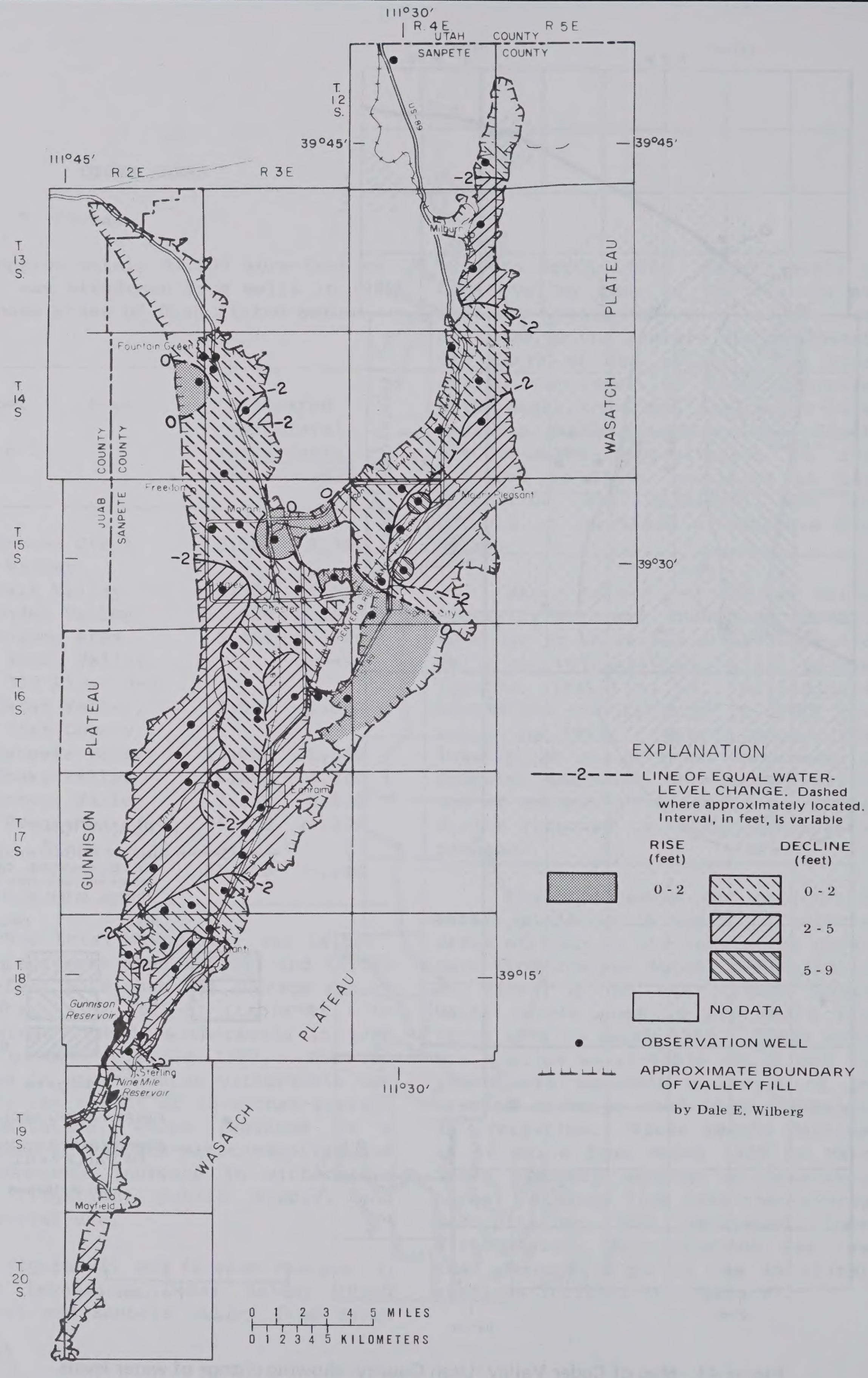


Figure 42.--Map of Sanpete Valley showing change of water levels from March 1988 to March 1989.

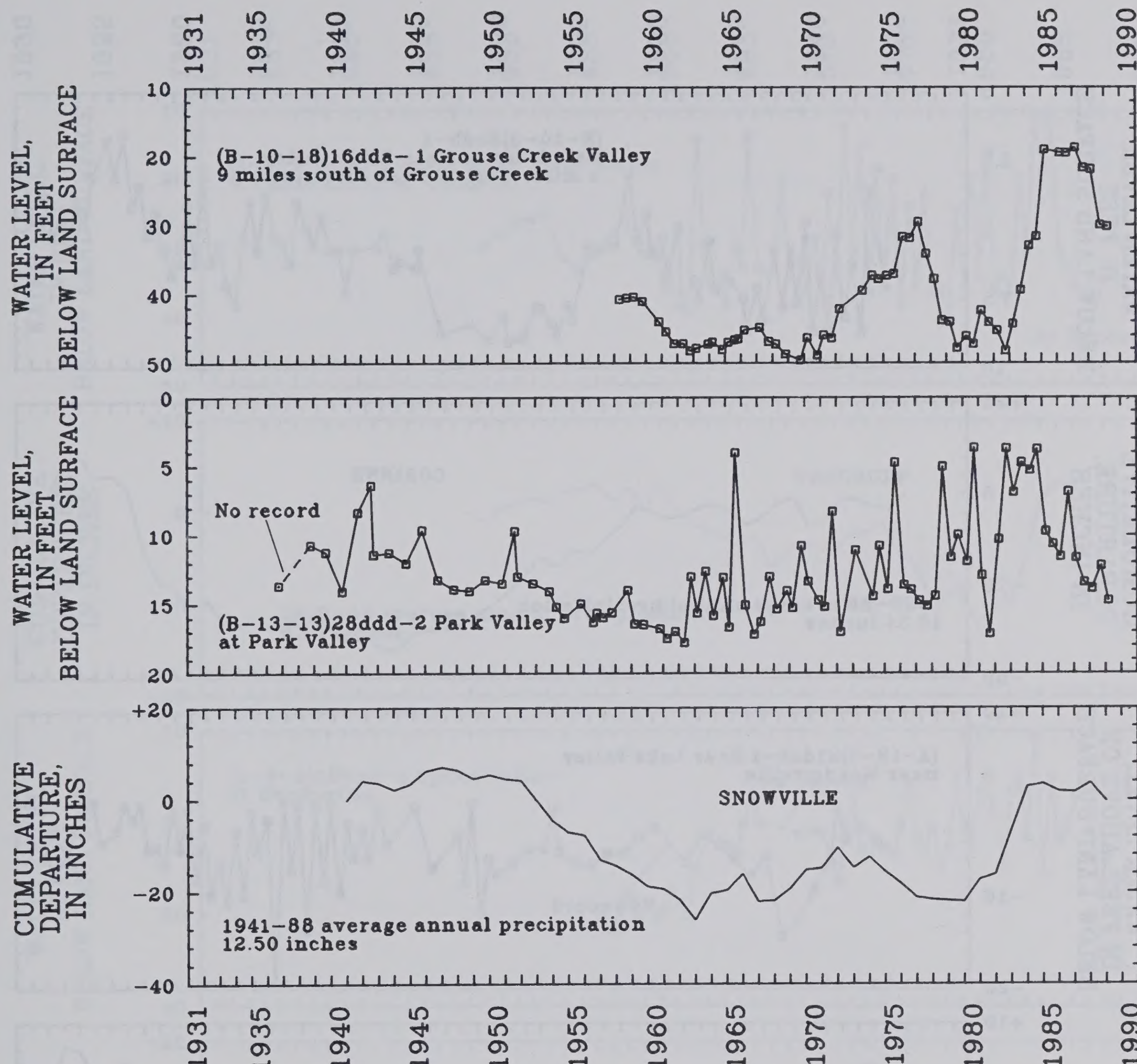


Figure 43.--Relation of water levels in wells in selected areas of Utah to cumulative departure from the average annual precipitation at sites in or near those areas.

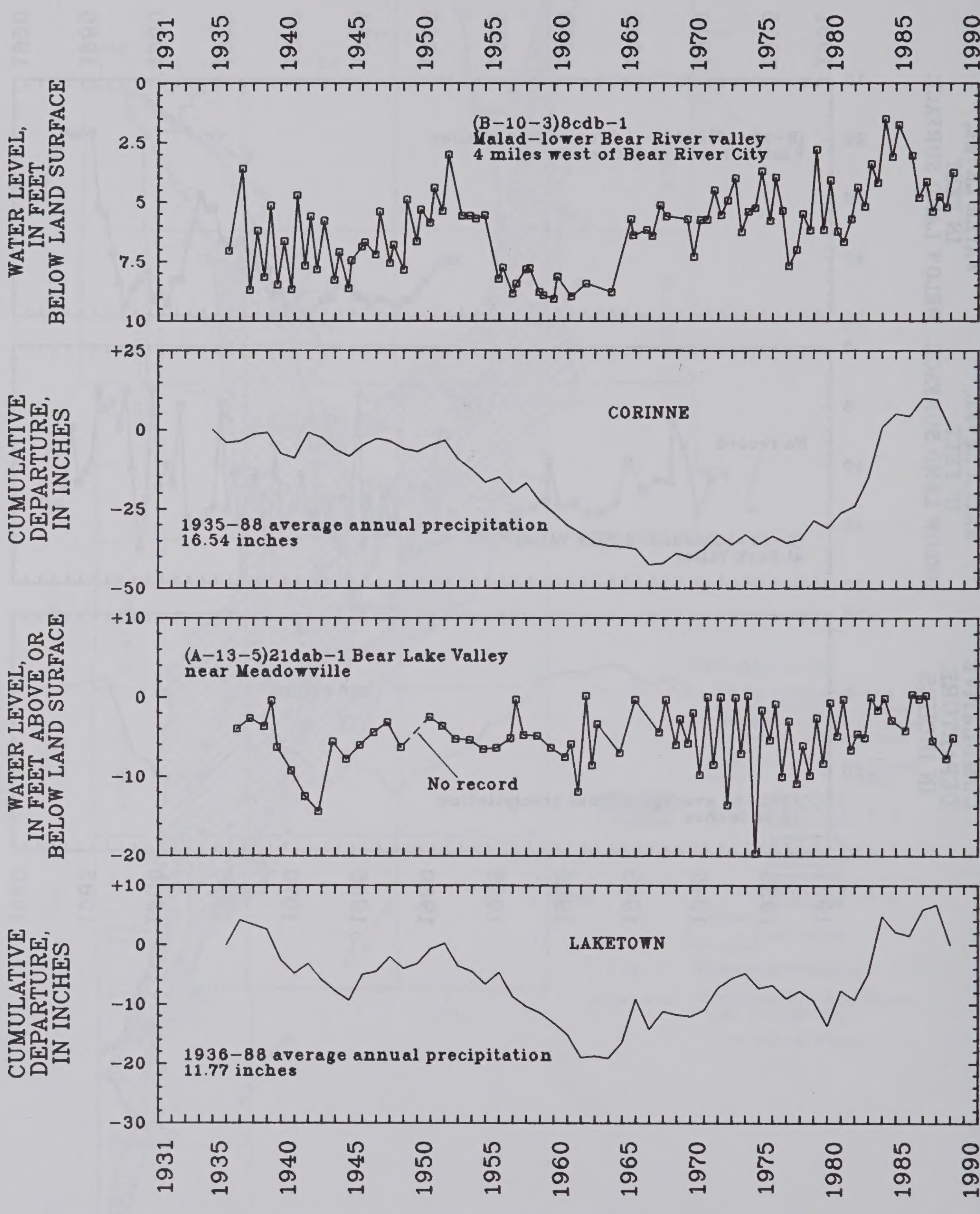


Figure 43.--Continued

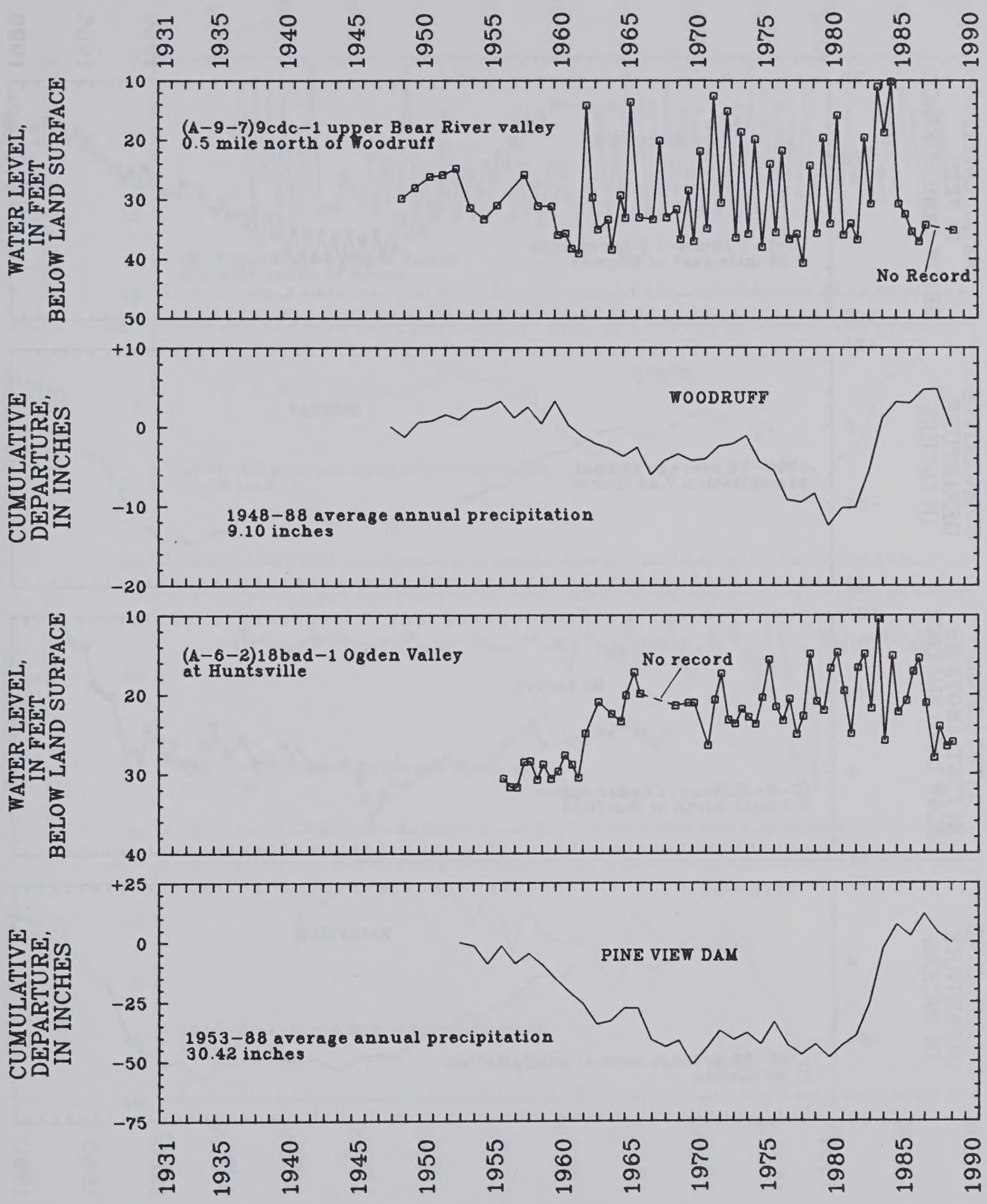


Figure 43.--Continued

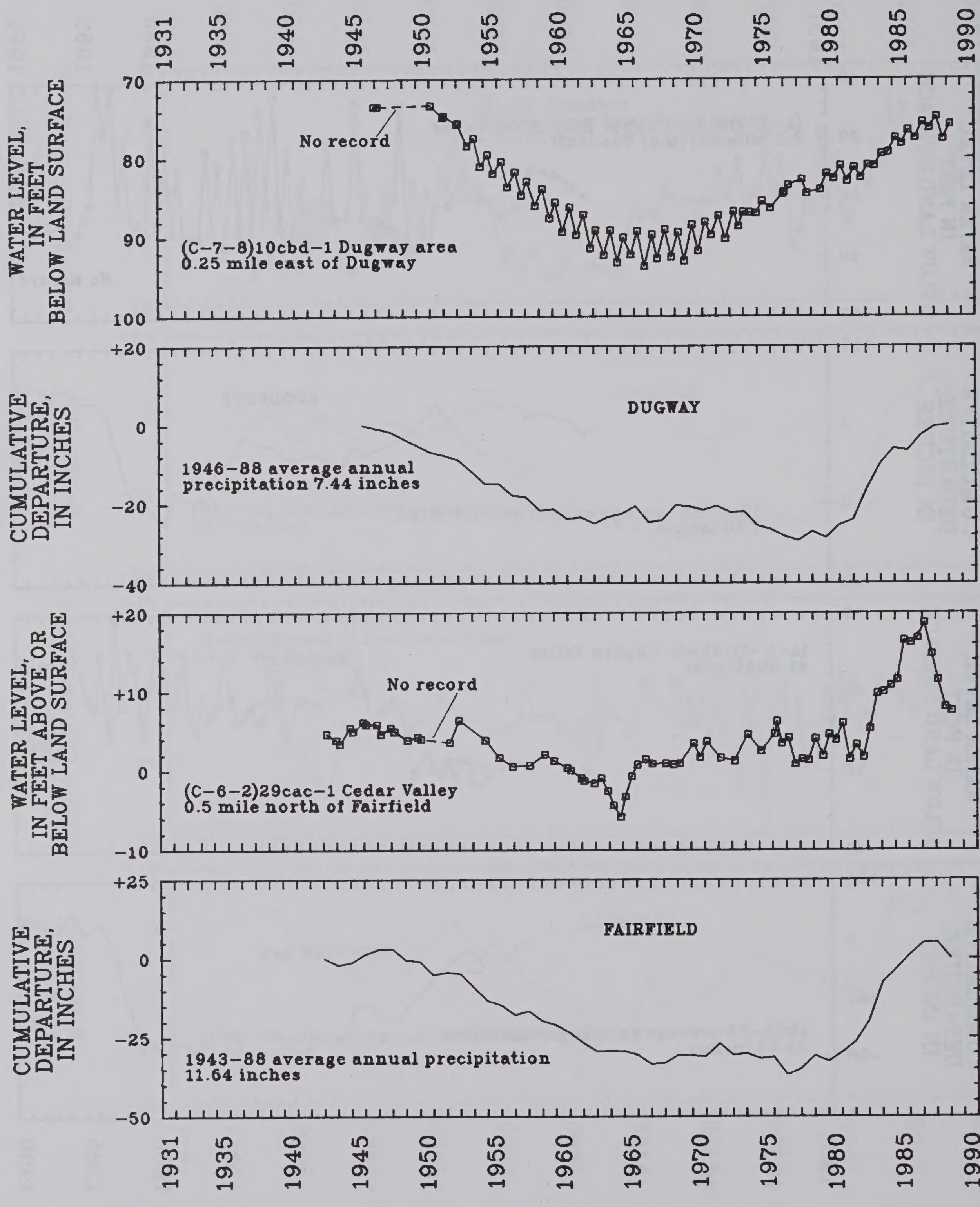


Figure 43.--Continued

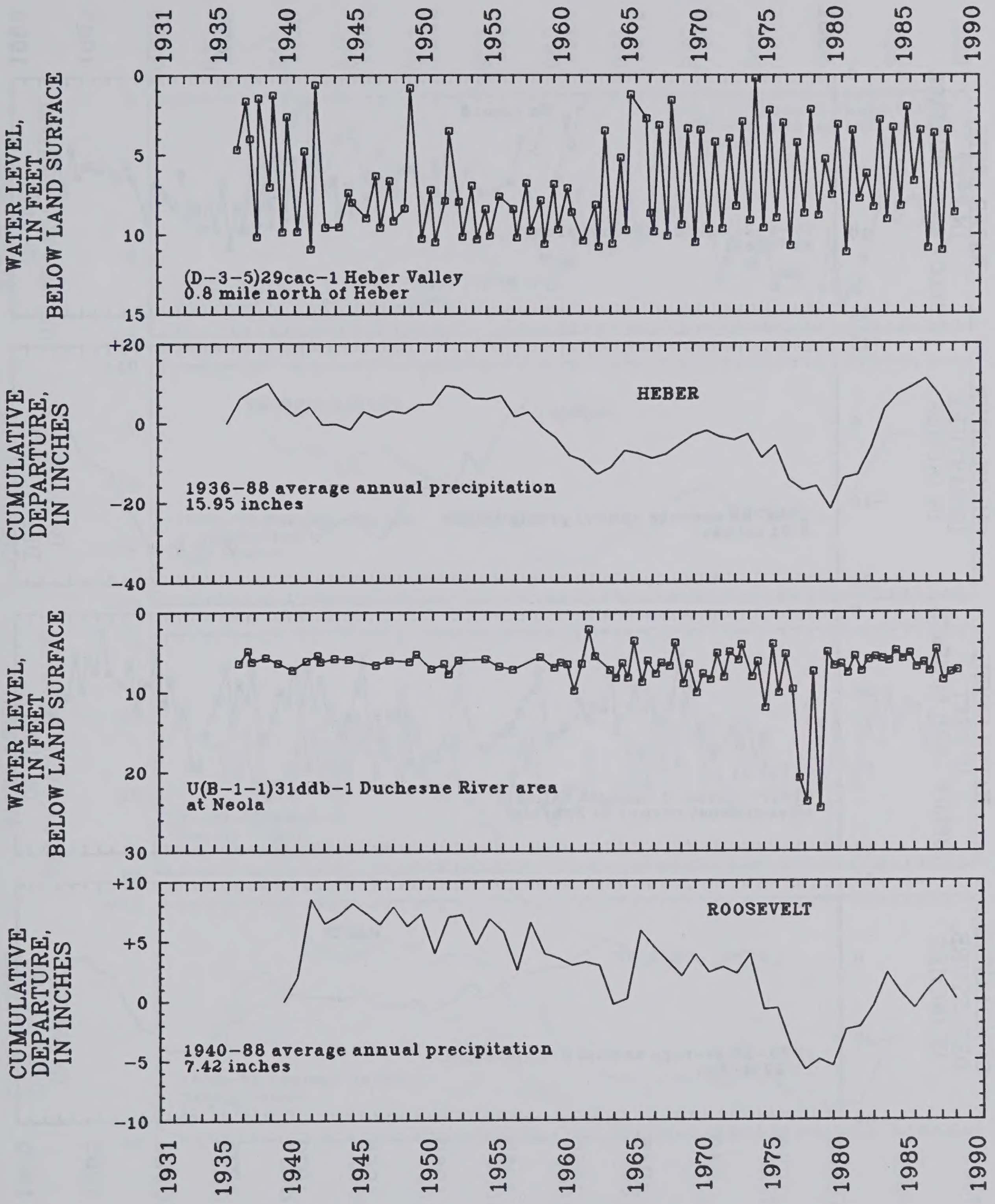


Figure 43.--Continued

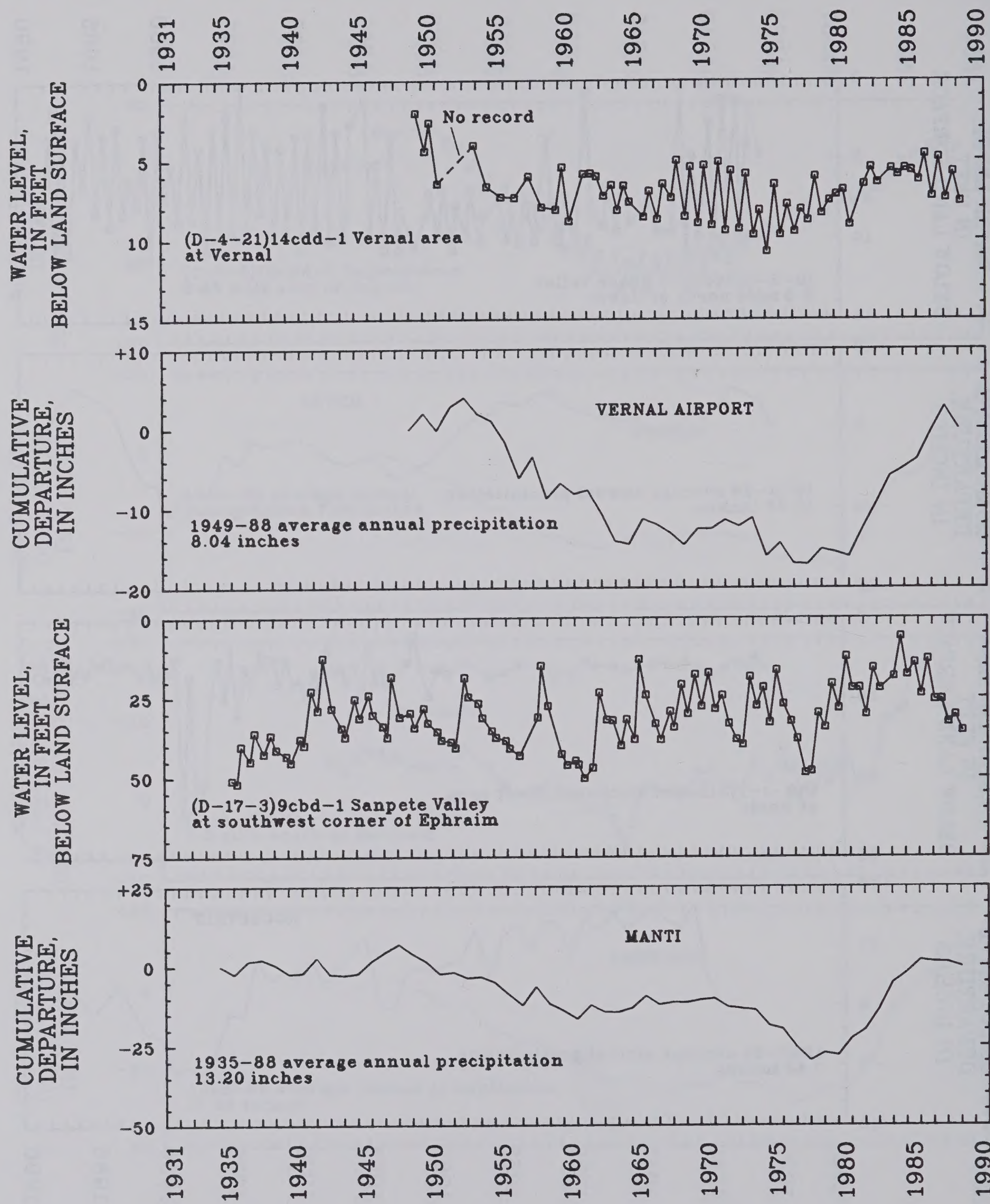


Figure 43.--Continued

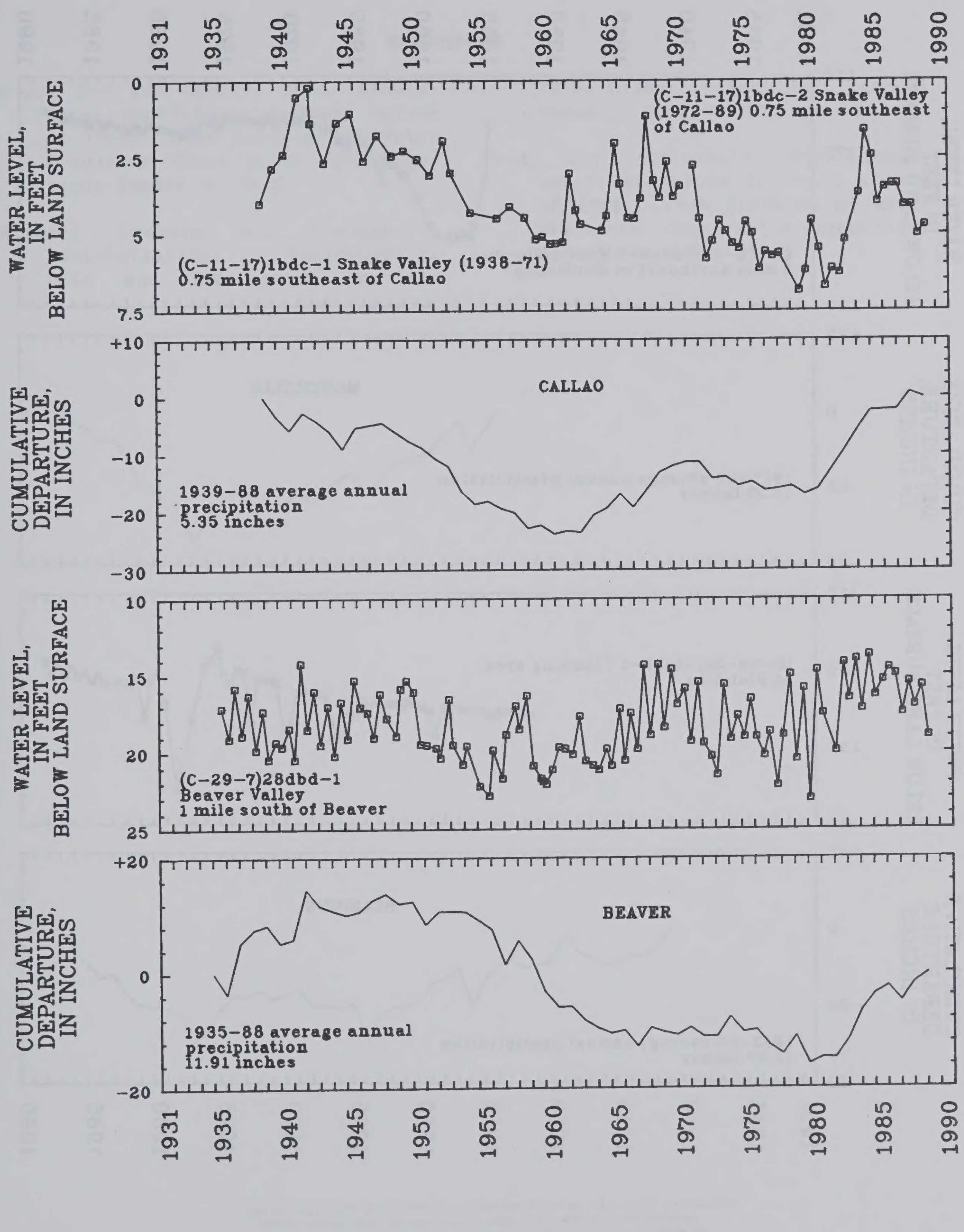


Figure 43.--Continued

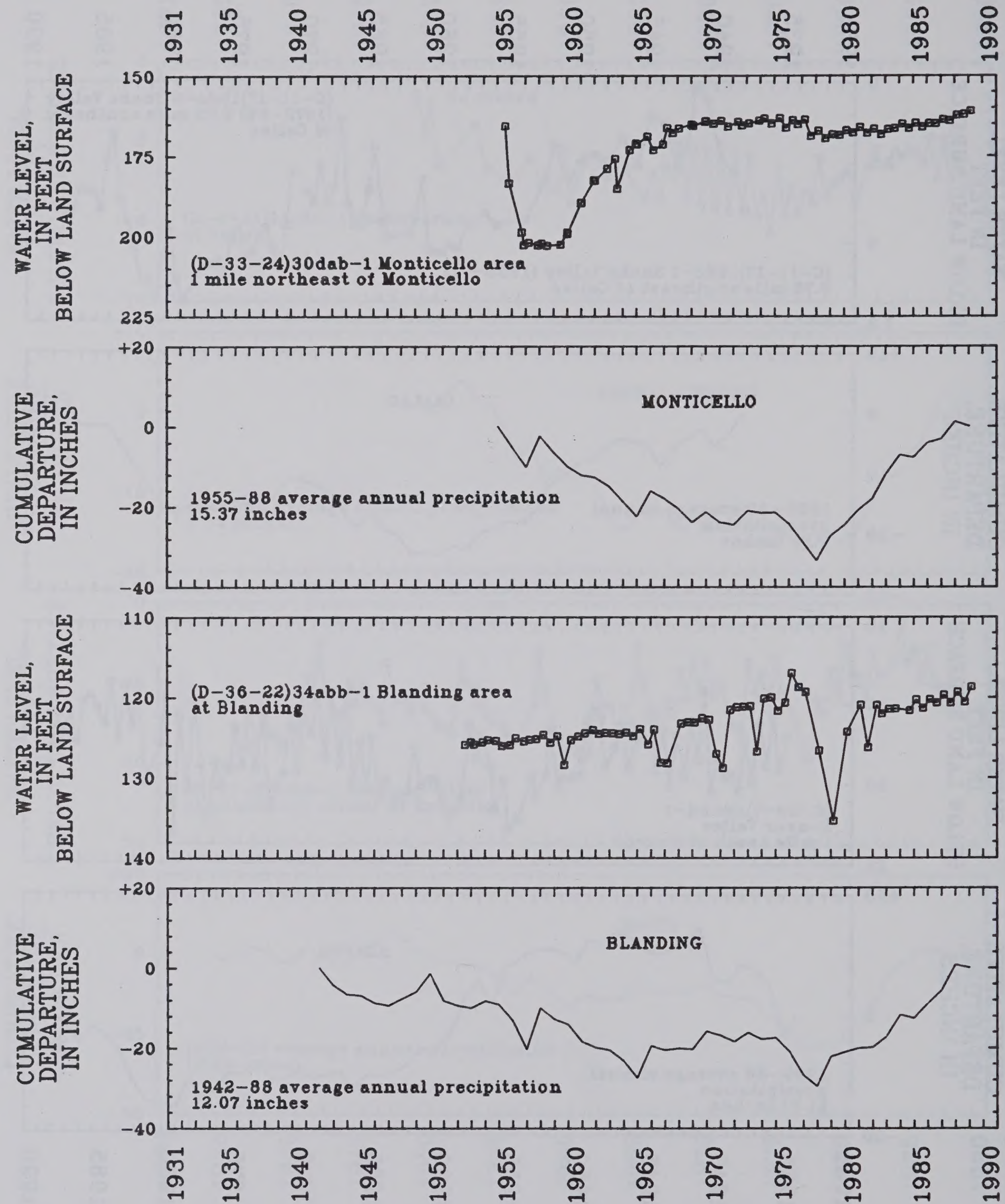


Figure 43.—–Continued

REFERENCES

Arnow, Ted and others, 1965, Ground-water conditions in Utah, spring of 1965: Utah Division of Water Resources Cooperative Investigations Report 3, 99 p.

National Oceanic and Atmospheric Administration, Environmental Data and Information Service, 1989, Climatological data (annual summary, 1988) v. 90, no. 13.

Cordy, G.E., and others, 1988, Ground-water conditions in Utah, spring of 1988: Utah Division of Water Resources Cooperative Investigations Report 28, 81 p.

UTAH
NATURAL RESOURCES
Water Resources